AGRICULTURAL ENGINEERING

JUNE • 1956

In this Issue . . .

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Case Engineering Scores Again with a Tractor That's Set a New

World's Record

for Fuel Economy

Case engineers . . . dedicated to the objective of giving farmers a 4-plow tractor without equal in performance, power and economy . . . have climaxed their efforts in the new 8-speed Case "400." Evidence of this achievement rests in recent, impartial Nebraska tests. Results show conclusively that the Case "400" is the all-time champion for low fuel consumption. With its Case-designed Powrdyne engine, more power was produced per pound of gasoline than any other tractor in the whole history of these official trials.

CASE "400"

Fuel economy is only one form of savings found in today's finest tractor in the 50-horsepower class. One of the many other examples is its Powr-Range transmission with eight overlapping gear speeds that keep power in balance with load. For all the exciting facts see your Case dealer or write for catalog and copy of World's Record report to J. I. Case Co., Racine, Wis.

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS • JUNE, 1956 • VOL. 37, NO. 6

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Associate Editor

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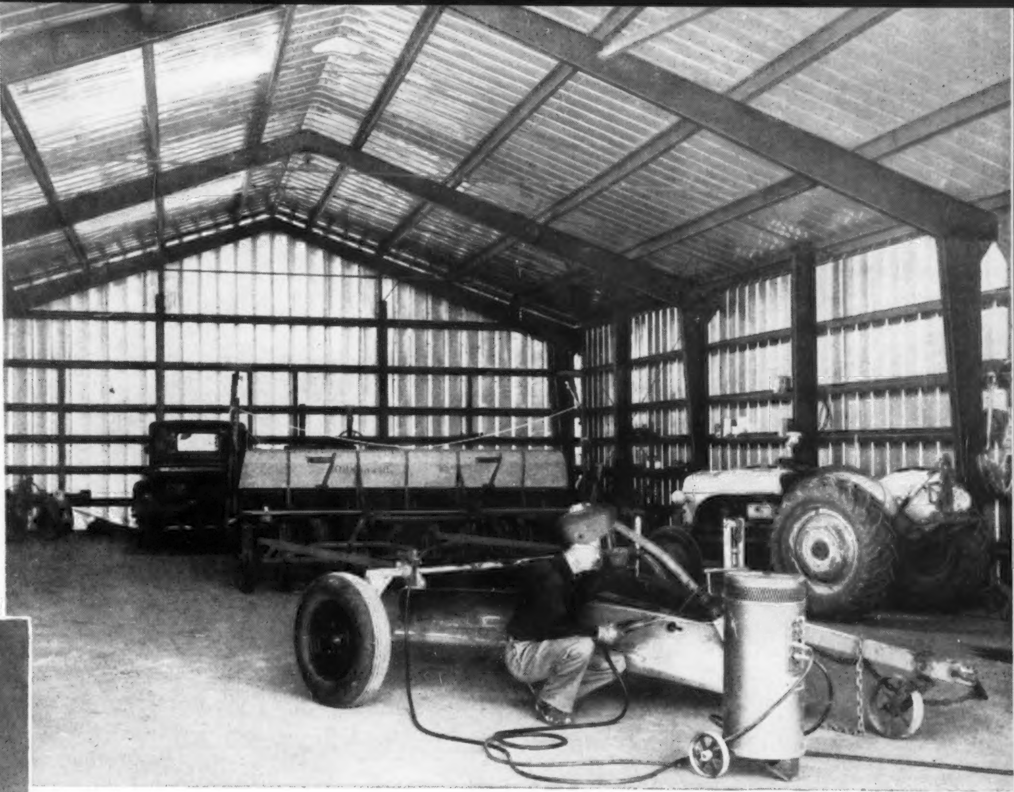
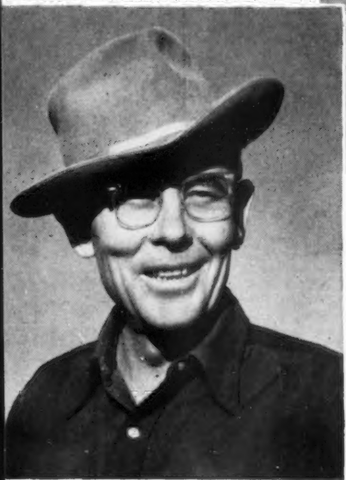
"**THIS STURDY,** convenient building is ideal for grain storage, machine shelter and shop facilities," says F. M. Greathouse of Garden City, Kansas. "I'd recommend it to any farmer in Kansas, or any other state for that matter. Its great structural strength permits piling grain 11 ft. high, is adequate for overhead crane for pulling motors. This building should last a lifetime, with a minimum of care. It's mighty good-looking too."





IN FAMOUS BUTLER FARM BUILDINGS

Roof purlins of USS MAN-TEN Steel

increase load-bearing capacity 72%, cost less to use than carbon steel

USS MAN-TEN Steel has higher strength with a yield point one and one-half times that of plain carbon steel. That is why the Butler Manufacturing Company, Kansas City, Mo., is making generous use of USS MAN-TEN in purlins, girts and eave struts in their steel farm buildings. For, by using high strength steels in these members, they are able to obtain more effective strength per dollar—greater economy than with any other material.

Here is what Butler Manufacturing reports: "We originally started making these purlins of 14-gage carbon steel, which — when properly spaced—carried a roof load of 15 lbs. per sq. ft. They weighed 62 lbs. each.

"As our business expanded, there was a need to furnish buildings capable of carrying heavier roof loads, so we turned to high strength steels. Now, made with 14-gage USS MAN-TEN Steel, our purlins weigh no more than before, but can support a load of 26 lbs. per sq. ft. To obtain this greater strength with carbon steel would require a member weighing some 93 lbs.

"We figure that on an average size Butler farm building—40 x 60 x 14—the saving of 31 lbs. per purlin results in a saving of 1600 lbs. of steel. This not only makes erection easier but materially reduces freight costs on the steel as well.

"To this can be added important savings in steel costs. The MAN-TEN Steel eave struts, for example, cost 83 cents less per piece—and purlins cost 97 cents less."

This application of USS High Strength Steel is typical. In these superior steels —USS MAN-TEN, USS COR-TEN and USS TRI-TEN—manufacturers of farm structures and equipment used on farms have at their disposal three service-tested steels that will permit them to materially increase the serviceability of their products at little or no increase in cost—and frequently at a saving. Find out how readily they can be applied to increase the strength and durability or provide longer life in vital parts of your equipment.

• • •

Send for a free copy of our 174-page "Design Manual for High Strength Steels." You'll find it extremely useful. Simply write to United States Steel Corporation, Room 5363, 525 William Penn Place, Pittsburgh 30, Pa.

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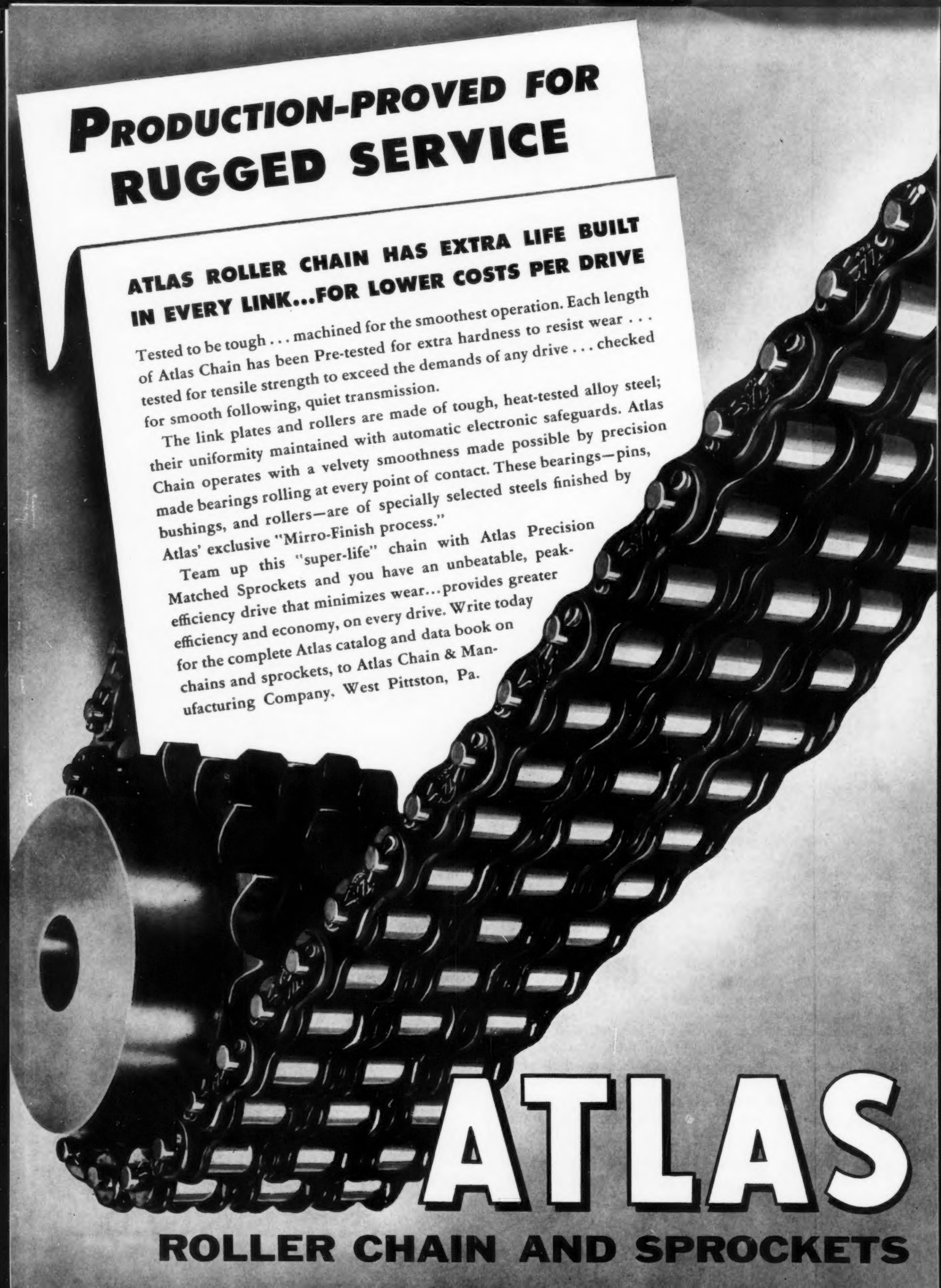
USS HIGH STRENGTH STEELS

USS MAN-TEN · USS COR-TEN · USS TRI-TEN

UNITED STATES STEEL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ATLAS ROLLER CHAIN HAS EXTRA LIFE BUILT IN EVERY LINK...FOR LOWER COSTS PER DRIVE
Tested to be tough . . . machined for the smoothest operation. Each length of Atlas Chain has been Pre-tested for extra hardness to resist wear . . . tested for tensile strength to exceed the demands of any drive . . . checked for smooth following, quiet transmission.
The link plates and rollers are made of tough, heat-tested alloy steel; their uniformity maintained with automatic electronic safeguards. Atlas Chain operates with a velvety smoothness made possible by precision made bearings rolling at every point of contact. These bearings—pins, bushings, and rollers—are of specially selected steels finished by Atlas' exclusive "Mirro-Finish process."
Team up this "super-life" chain with Atlas Precision Matched Sprockets and you have an unbeatable, peak-efficiency drive that minimizes wear...provides greater efficiency and economy, on every drive. Write today for the complete Atlas catalog and data book on chains and sprockets, to Atlas Chain & Manufacturing Company, West Pittston, Pa.
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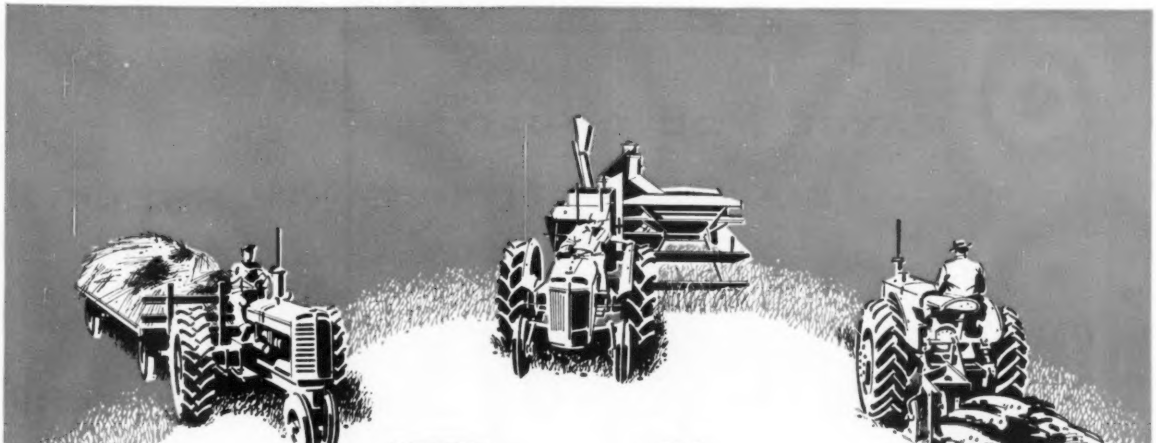

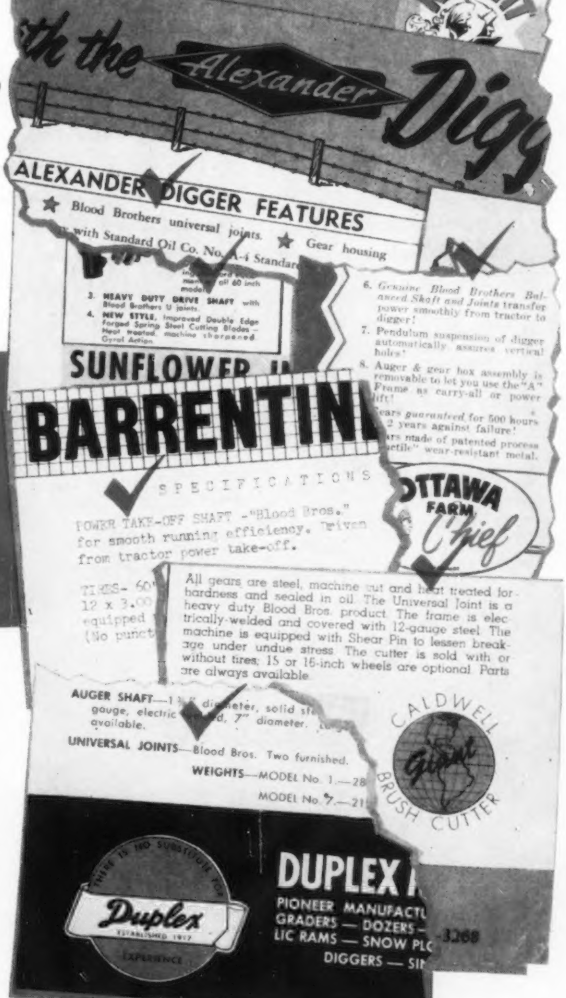

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MAKE GOOD PRODUCTS EASIER TO SELL

...so in advertising and literature, these machinery builders feature

✓ BLOOD BROTHERS Universal Joints and Drive Lines

Doctor, Merchant or Chief Engineer, you learn to prefer well-known products of high reputation—whether tires for your family car or component parts for your products.

These farm machinery manufacturers, too, have learned from past satisfaction that customers *respect and prefer to buy* implements with Blood Brothers Universal Joints.

So in catalogs and advertising, they *voluntarily* feature the dependable, uniform high quality of Blood Brothers Drive Lines.

Engineer, Purchasing Agent or Salesman—*you'll* find good products get extra preference (and perform better too) when they're Blood Brothers' equipped!

Write for engineering data and "Spec Sheet" Blanks.

BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

V-Belt equipped automatic transmission

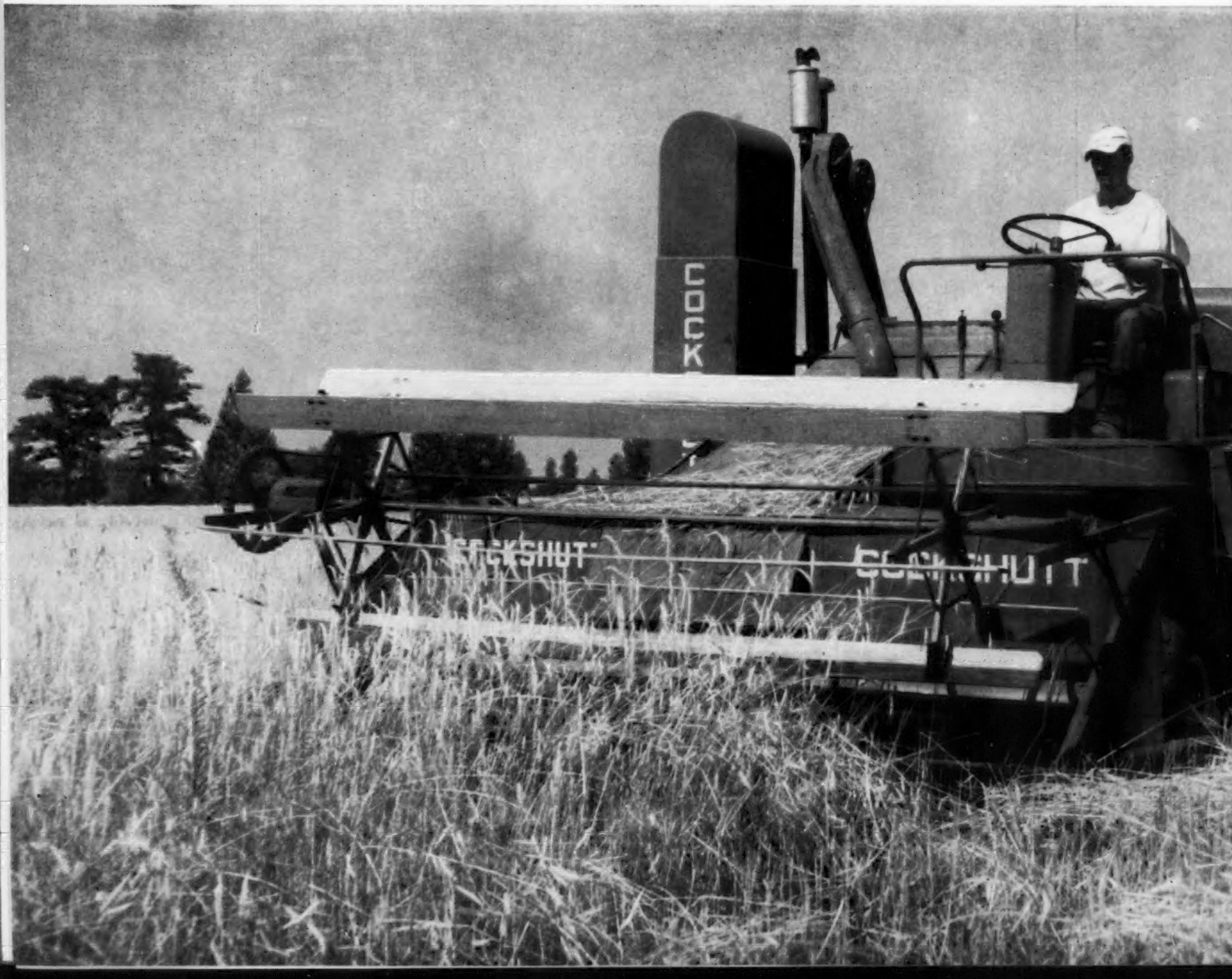
Dayton Double Cog-Belts* provide positive power, maintain speed ratios in tough vari-drive application.

Speeds instantly adjustable to crop and field conditions are obtainable with the newest self-propelled combine manufactured by Cockshutt Farm Equipment. Drive-O-Matic, a hydraulically controlled variable speed drive—equipped with a Dayton Double Cog-Belt—gives fully automatic power transmission to huge airplane type traction wheels.

Designed to make harvesting of any seed crop faster, easier, and more profitable, the new combine's foot-pedal controlled speeds permit the operator to balance crop intake with threshing capacity. This eliminates plugging and underloading, increases harvesting efficiency.

In addition the combine is equipped with a hydraulically controlled header lift and individually adjustable main drives to meet every crop and field condition. Cylinder speeds, for instance, range from 245—1178 rpm.

Study by Dayton Agricultural Engineers showed the following conditions affecting drive operation. Powered by a six cylinder engine the 14" OD driver sheave revolved at approximately 2000 rpm. The V-Belt, used as a clutch with a cam spring for tensioning, had to take a 60 hp maximum load. Belt slippage had to be eliminated, extreme flexibility was needed, and positive speed ratios maintained.

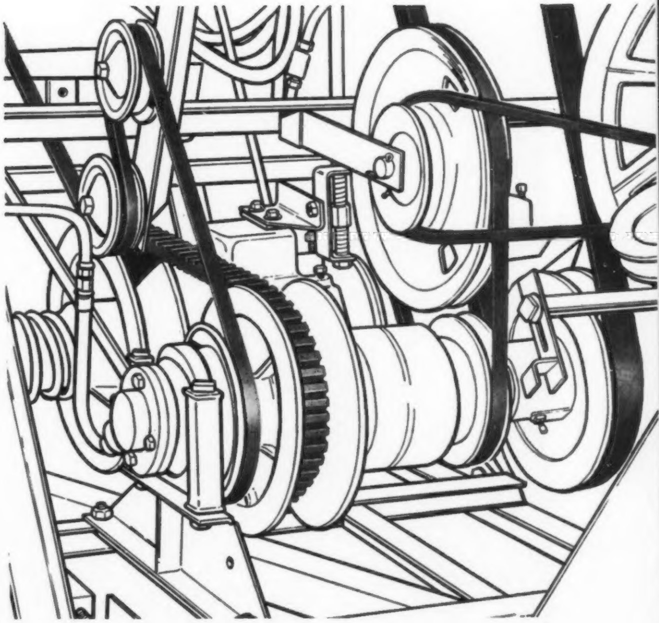


gives new combine $^{5}/_{8}$ to 9 mph range

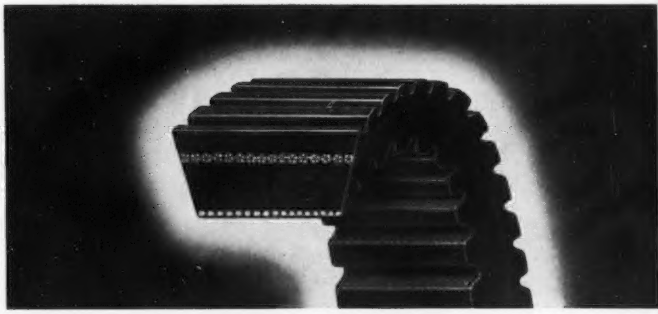
In order to meet *all* the conditions imposed by this drive Dayton Agricultural Engineers recommended a specially-built Double Cog-Belt. After severe field tests it was enthusiastically approved by Cockshutt Engineers for use on the new combine.

Consult with Dayton Agricultural Engineers on your next V-Belt Drive application. Your requirements can be met by one of Dayton's complete line of V-Belts, or, if necessary, a special belt can be designed to fit your needs.

Write The Dayton Rubber Company, Agricultural O.E.M. Div., 1500 S. Western Avenue, Chicago, Illinois.



V-Belt powered Variable Speed drive was more economical than any other method of producing automatic traction. Performance was equal or superior. Belt used is an "HD" Section specially-built Double Cog-Belt.



Die-cut, press cured sides provide non-slip contact with sheaves. Exclusive Double Cog design gives cross-wise rigidity necessary to maintain speed ratios, plus maximum longitudinal flexibility.

*T. M.

Dayton Rubber

51 YEARS OF PROGRESS

First in Agricultural V-Belts

Agricultural Sales Engineers in Atlanta, Chicago, Cleveland, Dayton, Moline, New York, San Francisco and St. Louis.

Case "400" Tractor and Case 11'6" S wheel harrow with Crucible LaBelle discs.

New Case tractor model 400, brings users the dependability of vital gears and shafts fabricated from nickel alloy steels to provide good surface wear resistance plus needed strength for rugged work. Manufactured by J. I. Case Company, Racine, Wisc.

Nickel alloy steel gears in Case tractors, despite severe abuse, keep running smoothly

In the new Case tractor, model 400, carburized nickel alloy steel gears meet tough operating demands and provide advantages for the manufacturer as well.

Gearing strengthened with 4620

Differential bevel gears and their mating pinions are fabricated of 4620 steel. This provides not only strength and toughness, but—thanks to minimum distortion in heat-treating — smooth and silent operation.

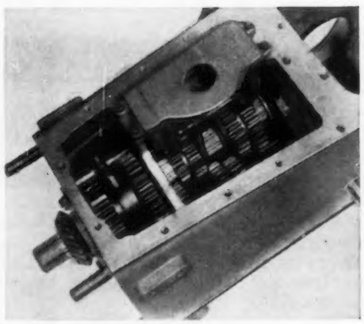
Case transmission and crankshaft gears are also of 4620 type nickel molybdenum steel, to obtain essential hardness, strength and wear resistance.

Shafting Improved with Ni-Cr-Mo-Steel

To provide high strength in torsion, Case specifies a direct-hardened nickel alloy steel — type 4340 — for model 400 power take-off shafts. This steel develops high mechanical properties, has excellent hardenability and responds readily to fabrication processes. Its high permissible tempering temperature also assures toughness and dimensional stability.

Have You a Problem?

Inco offers help to anyone with a metal difficulty...help based on long, practical experience...so don't hesitate to send us details of your problems for our recommendations.



Nickel steel gears impart stamina to these transmission units for the new Case 400. In addition to high mechanical properties, the nickel alloy steels for these components readily respond to heat-treatment and fabrication, thus permitting economical production.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

THE PACE IN FRICTION MATERIAL DEVELOPMENT

THE WORLD'S MOST COMPLETE

TESTING

ASSURES CUSTOMER SATISFACTION

Friction is an elusive phenomenon. To predict and control the performance of friction materials in new applications or combinations—particularly with today's precise operating requirements—is almost impossible except by actual proving on a vehicle or on a dynamometer.

That's why Raybestos-Manhattan, for over 50 years the world's largest maker of friction materials, has the world's most complete, most adaptable facilities for testing friction materials—both in the laboratory and on the highway.

Much of this test equipment was actually designed by Raybestos-Manhattan. In 1938, for example, R/M developed the first dynamometer ever made for the specific purpose of testing friction materials operating in oil.

R/M was the first to chart the properties of friction material operating in oil at speeds up to 18,000 rpm.

R/M dynamometers range from comparatively simple machines to giant inertia dynamometers—including one of the world's largest—on which customers' complete brake and clutch parts can be tested so as to bring out inherent design factors, such as servo, wrapping, distortion, and expansion due to heat.

There are certain factors—character of engagement, for example—that cannot be accurately evaluated in the laboratory. R/M therefore maintains its own vehicles for road testing brake linings, clutch facings and other friction parts under actual operating conditions—and on both level and high mountain country. At the well-known Jennerstown Mountain Testing Area, R/M maintains a year-round testing station where friction parts can be subjected to rigid tests under the most rigorous driving conditions . . . on grades up to 15%.

WHAT DOES THIS R/M TESTING MEAN TO THE O.E.M.?

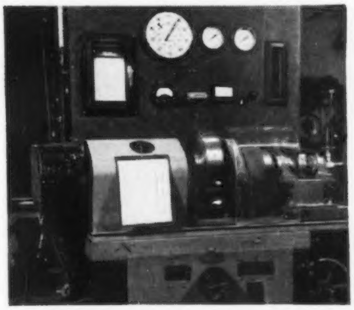
It means, first, that friction material performance in full size brake and clutch assemblies of trucks, airplanes, buses, trains, off-highway equipment, and passenger cars may be thoroughly and accurately explored for you by R/M engineers.

It means, second, that R/M has acquired knowledge of the behavior of friction materials under a wide range of operating conditions that provides exact answers to problems you may be facing now.

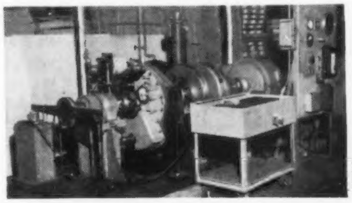
Unlike most other manufacturers, Raybestos-Manhattan works with all kinds of friction materials—from woven and molded asbestos to cork-cellulose and sintered metal. Consequently you are assured of the *best and most unbiased advice* on friction materials when you call in an R/M engineer.

If you are working with friction materials—and wish to make that work more productive and more profitable—consult with an R/M representative. All of R/M's experience in friction and the complete facilities of its seven plants—with their research and testing laboratories—are as near as your telephone.

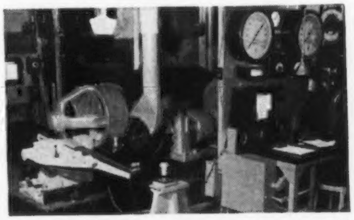
Friction material fade and wear characteristics are tested on this Long clutch machine at R/M plant in Manheim, Pa. Two clutch tests can be performed simultaneously here.



Transmission dynamometer at Bridgeport developed by R/M for complete testing of automatic transmission plates.



Heavy duty master wet clutch dynamometer at R/M plant in Crawfordsville. This dynamometer was built to test plates for the master clutch of a heavy-duty tractor. Speed and torque can be varied to match all service conditions a tractor will encounter.



Heavy-duty inertia dynamometer at R/M plant in Bridgeport used for special testing. Aircraft landing and take-off conditions, for example, can be approximated on this machine—with brake temperatures rising from 0° to 1500°F in 6 seconds.

Write for your free copy of R/M Bulletin No. 500. Its 44 pages are loaded with practical design and engineering data on all R/M friction materials.

R/M

FIRST IN FRICTION

THE TRADE-MARK THAT SPELLS PROGRESS IN FRICTION MATERIAL DEVELOPMENT

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FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Canadian Raybestos Co. Ltd., Peterborough, Ont.

RAYBESTOS-MANHATTAN, INC., Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose
Industrial Rubber, Engineered Plastic, and Sintered Metal Products • Rubber Covered Equipment
Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls

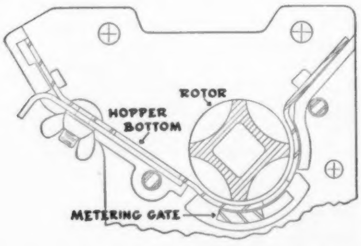

1ST

Why Armco Stainless Pays Off in Fertilizer Applicators

Armco Stainless Steel in vital parts on fertilizer applicators assures long, trouble-free service life.

Today's mechanized farming demands long and dependable service from mechanical equipment. This is why agricultural engineers are changing specifications to stainless steel for vital parts exposed to highly corrosive and abrasive conditions.

Take fertilizer hoppers, for example. Carbon steel offers little or no resistance to corrosive attacks from fertilizer chemicals. Paint doesn't hold up under the abrasive action of dry fertilizer. So corrosion on discharge mechanisms and hopper bottoms can destroy the carefully calculated delivery rates of valuable plant foods. In addition, corrosion causes costly delays and premature replacement of parts.



Here's where Armco 12 (Type 410) Stainless Steel gives dry fertilizer applicators assurance of top performance.

STAINLESS SCORES HIGH IN ACTUAL SERVICE

Here's what one manufacturer had to say about Armco 12 (Type 410) Stainless Steel as a solution to the problems of corrosion and abrasion:

"Our engineering department decided to use stainless in these parts for several reasons—long life combined with accurate delivery rates. It is absolutely necessary that the rotor flutes and metering-gate openings remain free of corrosion from the effects of fertilizer chemicals so they do not afford a foothold on which fertilizer can begin caking or clogging. From our applicators in the field, we find tnat these stainless parts are performing very satisfactorily."

FOR LIQUID FERTILIZER TOO

In the far west where liquid fertilizer is distributed via irrigation water, one manufacturer found the solution to his corrosion problem in tanks made of Armco 18-12 Mo ELC (Type 316L) Stainless Steel. These tanks are used as containers for technical green phosphoric acid and ammonium nitrate solutions.

The tank manufacturer pointed out that this Armco-developed grade of stainless steel "withstands the corrosion of both types of chemicals." He added that no other metal or coating on metal will do this satisfactorily and still be practical economically.

Liquid fertilizer tanks made of Armco 18-12 Mo ELC (Type 316L) Stainless Steel resist severely corrosive chemicals.

STAINLESS CAN HELP YOU

If you have corrosion problems in your fertilizer equipment, consider changing to Armco Stainless Steel for vital parts. Armco produces a wide variety of standard stainless steel grades, in addition to special grades in sheet, strip, bar, and wire. Armco engineers will be glad to work with you in determining the right grade to use. Just fill in and mail the coupon on this page.

ARMCO STEEL CORPORATION
1486 Curtis Street, Middletown, Ohio

Send me your catalog on "Armco Stainless Steels"

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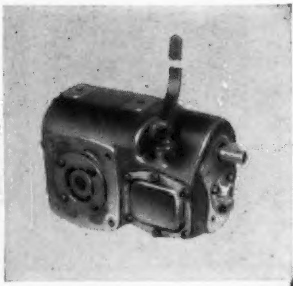
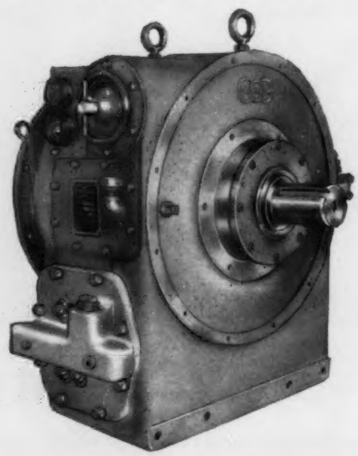


How to Make Sure of Superior Performance

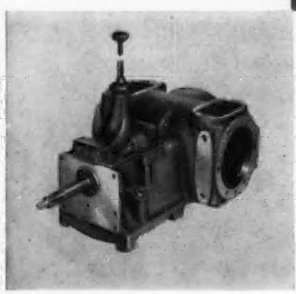
CLARK-TORCON CONVERTER UNIT



Who can build the best machine!—that is the modern spirit of American Industry. And the intensity of that competition is a major reason why leading manufacturers are using Clark engineering cooperation in designing new equipment—highway and off-highway, automotive, industrial, and construction.

For *Clark knows the transmission of horsepower:* has specialized in that basic field for more than 50 years; knows what can be counted upon to work—and what will not . . . The drive-units pictured here were designed to *make sure* of superior performance. They are hard-working, rugged, dependable proofs that it's good business to do business with Clark Equipment.

Send for attractive pocket-size booklet "Products of Clark".



CLARK EQUIPMENT COMPANY
JACKSON, MICHIGAN
Other Plants:
Buchanan, Battle Creek, Benton Harbor, Michigan

CLARK EQUIPMENT

AGRICULTURAL ENGINEERING

VOL. 37 JUNE, 1956 No. 6

Land Smoothing for Improved Drainage

J. W. Borden
Member ASAE

Land levelers or smoothers, rapidly gaining in popularity as aids in both drainage and irrigation practices, have proven especially useful in facilitating uniform distribution of surface water, with the result that erosion is minimized, more water enters the soil, and earlier planting, maturing, and harvesting of crops is made possible

SINCE 1950, when the subject was first presented (1)*, land smoothing has received much attention in many sections of the Midwest, East and South. Federal and state technicians in many areas have included the study of land smoothing in their research programs. Agricultural engineers, agronomists and soils technicians have produced new information that constitutes the foundation for this paper.

During the past five years, field technicians, who work directly with the farmers, have also become interested in land smoothing, and many farmers have experienced noteworthy results from it. It was recognized and included in the 1952 federal agricultural conservation program bulletin, and many states, including Iowa, Illinois, Indiana, Ohio, Wisconsin, and Louisiana, have included the practice in their state bulletins.

Land smoothing may be defined as "grading or planing the ground surface by mechanical means to eliminate or reduce elevated areas and fill minor depressions." Its purpose is "to provide a more uniform plane on which surface runoff can move unobstructed into field drains without impounding." The key to surface drainage is "to keep the runoff water moving without causing erosion of the land surface or the ditches."

Land smoothing is needed as an integral part of all types of field-surface drainage to accomplish the objective of ridding the land of excess water quickly. The effectiveness of a surface-drainage pattern is a measure of the movement of surface water uniformly from the entire field following heavy rains. The ironing out of surface irregularities to utilize the natural slope of the land and permit the water to move into the field outlets can be accomplished only by systematic annual or frequent smoothing operations. It is necessary, of course, that outlets be provided to carry the surface water from the field and from the farm.

"Land forming" and "land shaping" are terms which have come into prominence recently in many areas. Land forming and land shaping encompass a wide variety of farming practices, consisting of one or a combination of practices, including land leveling, precision grading, land smoothing, subsoiling, deep tillage, filling of gullies, grassed waterways, open ditches, surface drainage ditches, diversion ditches or terraces and other practices, which increase crop yields by control of water in an orderly manner by altering the surface and/or the subsurface of the field.

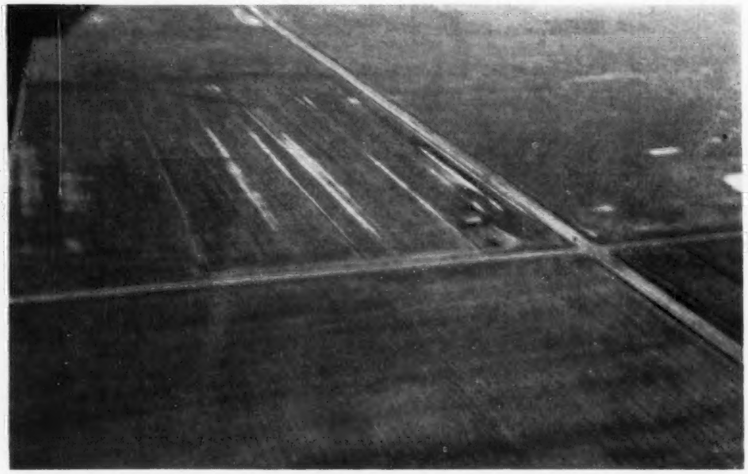
It makes little difference what kind of land the farmer works; the water that is necessary to produce his crops also helps to create his most difficult problems. If he is irrigating, either by gravity or sprinkler methods, his major task is to shape his fields to obtain uniform distribution of water to each plant in the field. In heavy rainfall areas, on either extremely flat land or on fields with claypan subsoils, land preparation is needed to provide satisfactory drainage. In many areas, a flat field has two drastically different water problems during crop growth. During a wet period it may be water-logged and in need of improved drainage, whereas, during the dry period of the crop cycle, supplemental irriga-

Abridgment of a paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1955, on a program arranged by the Soil and Water Division.

The author—J. W. BORDEN—is vice-president in charge of sales, Eversman Manufacturing Co.

*Numbers in parentheses refer to the appended references.

Land smoothers or levelers are gaining increasing favor in humid areas for drainage and better farm management



Aerial view of Mississippi River bottom land near Canton, Mo. The field in the foreground has been worked with a land smoother for several years. Fields at the top of picture indicate that potholes have trapped water which will delay farming and cause crop damage

tion water may need to be applied. On rolling land, gully and small wash elimination followed by drainage-type terrace construction to carry the water off the field may be essential. Assuming the field presents no other problem, the simple fact that the most efficient practice may be to use bigger, faster and more efficient machines on larger fields, points up the desirability of better land preparation.

Of all land-shaping practices, land smoothing is probably the cheapest and yet one of the most productive. It will supplement all of the other land-forming jobs and make them more efficient. Land smoothing is economical since it can be done with the standard farm tractor and, after the initial field-contour correction, it can be included each year as part of the tillage operation in preparing the seedbed.

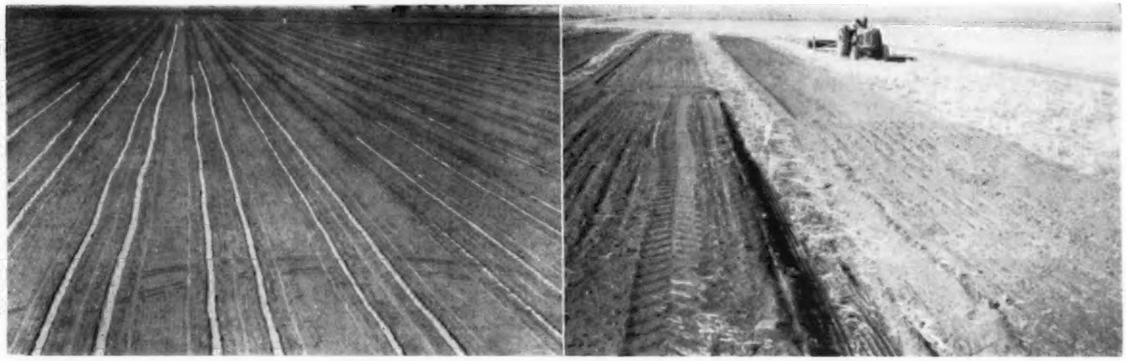
At this point, the question of maintenance might well be mentioned since this vitally important point is oftentimes overlooked. Land-forming practices require year-to-year maintenance to retain their efficiency. Once a field has been prepared properly to achieve good surface drainage, the ordinary crop cycle involving plowing, planting, cultivating, and harvesting, to say nothing of the water and wind action during the course of the year, will disturb the surface enough to impound water that will result in crop damage. Saveson (4), in discussing the necessity of the yearly maintenance operation, refers to the cropping-cycle irregularities as "implement scars" and points out the need to erase them before each crop.

A close relationship exists between tillage and land smoothing. There is a definite correlation between smoothing an entire field so that it will drain or irrigate properly and a small area of the field, say, a square yard, that receives additional benefits from the smoothing effect in addition to the drainage obtained. A better, more uniform job of fertilizing results since the applicators are held at a constant depth. The plowing job is better since the shares operate at a constant depth and do not sink lower in wet spots or raise out of the ground on high, hard, dry spots. The planter will place the seed at the correct depth. Since the area is well drained, earlier planting is possible. The firm, well-prepared seedbed will retain sufficient moisture to germinate the seed, even if the weather becomes dry. The resulting uniform stand will result in even crop growth throughout the year and uniform maturity at harvest time. It permits closer and more complete cultivation, and for combining close-growing crops, such as soybeans, less field loss will occur. Pickup devices do a more efficient job by operating on a smooth surface. On pastures and meadows, mowing, raking, harvesting or baling is easier and faster on a smooth field. Results reported from all sections of the country continue to show the effects of land smoothing in correlating drainage and tillage operations.

Uses and Results in Various States

Wisconsin. On the Alameda silt loam and other poorly drained soils of the Spencer group in north central Wisconsin, significant yield increases were obtained on corn, small grain, oats and forage production during surface drainage research studies (2). The yield increases attributed to smoothing and drainage terraces were obtained during the years when the rainfall was below average, circumstances that would not permit this type of drainage system to demonstrate its maximum effectiveness. Land smoothing was found to be the single most effective surface-drainage practice on land slopes of 2 percent or less. A system of interception ditches is generally necessary to produce the most

(Left) A field in Illinois showing lack of good surface drainage • *(Right)* Photo of a field in the same area taken the same day in which the field had been leveled each time it was plowed for the past four years



(Left) This irrigated field was prepared with a small land smoother showing that there are no low places to drown out crops and no high spots to burn • *(Right)* Land grading with a small leveler and farm tractor. By making long, shallow cuts and following a definite pattern of working in strips this operation is done with close accuracy

efficient drainage system in order to provide for *(a)* the earth required to fill or drain field depressions, *(b)* the creation of the necessary land-surface gradients, *(c)* reduction of overland flow of the runoff, and *(d)* the increase in velocity of the concentrated runoff flowing into the ditch channels. The installation of a drainage system partially compensated for a relatively low level of soil fertility, as yields from ditched areas that had received no commercial fertilizer equalled and often exceeded the yields obtained from unditched areas which had received fertilizer.

Louisiana. In Louisiana, the land-smoothing operation has been incorporated into other land-preparation practices, namely, grading to establish a definite slope on flat fields. Graded and smoothed test areas, in Louisiana, showed an average increase of 5.81 standard tons per acre (worth approximately $45) of sugar cane over the ungraded check area in the first cycle of cane. The second cycle of cane continued to show an increase over the check area. In many cases the cost of grading sugar-cane land is liquidated by the increased yields the first year, and the increase in yield the following and subsequent years is net profit. The grading and smoothing of typical average sugar-cane land required from 4½ to 5½ hr per acre. Most areas were graded and formed by earth-moving equipment to within two inches of the desired grade, and the land smoother was then used to finish the fields. Some preliminary work was started in Louisiana this year, primarily to develop methods and costs, in order to study the effect of surface drainage in the cotton areas. On a recent cotton test area, land smoothing was done prior to running levels and establishing the grade. This is recommended particularly if stakes are placed at 100-ft intervals, since one or two passes with the land smoother will eliminate many of the small surface irregularities and give a more accurate topographic map of the area surveyed.

Missouri. Field trials in Missouri during the 1952 and 1953 crop seasons show interesting results. In these field trials, there was no actual dirt moving accomplished, but rather the tests were set up to compare methods of seedbed preparation with a tandem disk and a land smoother. On flat fields of Putnam silt loam soil, the corn crop showed a yield increase of 5.1 bu per acre in 1952 on the portion of the field which was prepared with the land smoother, while the yield difference in 1953 showed a 11.3 bu per acre increase on the smoothed portion. During these same two crop years on flat fields, the soybean yields between the disked and land-smoothed portion were not significant. The variation of both the stand and yield was greater on the disked area than on the smoothed area. This indicates that on the smoothed area a somewhat superior stand was realized, since a more uniform planting depth was possible. There was insufficient rainfall during the two above-mentioned crop years to cause noticeable ponding on both the corn and soybean fields so the tillage effect of land smoothing must have been responsible for the yield increase. Observation on an adjacent terraced field (3 percent slope) indicated that the portion that was disked did not eliminate the small field ditches, and that runoff concentrated in these ditches sufficiently to cause the contour rows to break at these points and form silt bands in the terraced channel below. On the smooth portion, there was not sufficient concentration of runoff to cause rilling or channel silting when the runoff water passed from one contour row to another. Soybean yields, on the terraced area, showed an increase of 5.1 bu per acre in favor of the area on which the land smoother was used.

Alabama. The Alabama experiment station at Marion Junction, has had excellent results with land smoothing for the past seven years. In the heavy clay soil area there, very little land preparation is done, except for putting in fall and winter grazing crops. The primary problems there are concerned with water pockets and preparing a suitable seedbed by breaking up clods. At this station they have settled on a method of preparing a seedbed using only a heavy offset tandem disk and the land smoother. They find that with this equipment they can make a suitable seedbed with the least amount of effort and expense. At the same time, they obtain a smooth field with no pockets, so that small grain crops can be seeded in the fall without being drowned out in the wet season.

Georgia. At the Georgia Experiment Station, work with land-smoothing equipment has been similar to some of the projects conducted in Alabama, including surface drainage correction, preparation of land for gravity irrigation, leveling mounds left after pulling up old peach trees, reclamation of eroded areas and as a dirt-moving tool for building irrigation ponds. At another Georgia station, work is under way to study drainage and development problems of the Bladen soil areas. With surface drainage being the major factor under consideration, pockets and irregularities must

be corrected. The basic grading and smoothing job on this bedding study has been completed and the area left to fallow. This will provide maximum opportunity for dirt settlement, after which the land will be smoothed again and the final beds constructed.

South Carolina. In South Carolina, there has been some land preparation for surface drainage work on river bottom land near Clemson. This project, on 100 acres, consisted of land forming by bulldozing to move large quantities of dirt short distances and then cutting a V-shaped ditch with a road grader. This ditch followed the natural slope of the land and had a drop of 7 to 8 ft in the 3500-ft length. After the preliminary work was done, a land smoother was used for the remainder of the leveling job. The smoother was run over the entire field two or three times in different directions, and in some places a dozen times to correct the grade and eliminate all minor irregularities. In another area in South Carolina, land smoothing has been incorporated with a terracing program and found to be effective in removing undesirable ridges and depressions, shallow gullies and similar irregularities in contour which normally make too many undesirable kinks in a terrace system. Thus far they have installed parallel terraces on approximately 50 acres of land which they report "could not have been satisfactorily terraced for mechanized farming without using a land smoother."

North Carolina. There are several projects of interest which are either started or in the planning state in North Carolina. One of these, in the northeastern part of the state, was a study of combined mole and surface drainage on a tract of organic soils. Last year they found that even with a well-designed system of surface drains, there was still considerable damage from poor drainage and flooding, mainly due to numerous low spots that had no outlet to the surface ditches. This past spring land smoothing was incorporated into this project. The improvement in surface drainage and success of the land-smoothing job was proven in two ways. First, the landowner refused to let the leveler be returned to the experimental station, and, second, other research personnel in the state had their interest in land forming stimulated to the point of formulating additional water management studies and plans. Other technicians in North Carolina also believe there are a number of crop and soil problems in the state where a moderate amount of land forming would greatly improve surface drainage and yields.

Virginia. In the Virginia coastal plain area, there are many soils with a very low rate of internal water movement, and surface drainage is very poor due to natural depressions, that is depressions created by tillage practices and those due to relocation of drainage ditches. These depressions vary in depth from one to several inches, and from a fraction to more than an acre in area. Crop damage is severe in the pockets during wet periods, and complete crop failure occurs in years when the entire growing season is wet. In this area it is accepted practice to plant on top of bedded rows, and then dig a small drain ditch across the rows from each depression to the nearest lateral drainage ditch. These drains are spaced not more than 150 to 175 ft apart. On a field with 0.2 percent slope, a series of row lengths, ranging from 100 to 600 ft in length were studied. Tests for one year only (1954) on soybeans indicated no significant difference in yields between plots of different row lengths. This would indicate that the present drain spacing of 150 to 175 ft could be increased to at least 600 ft if a small amount of grading and land smoothing was done.

New York. In New York there is considerable interest being expressed in the interrelation between surface drainage, seedbed preparation and soil structure maintenance, since the mechanics of planting a crop does not permit the separation of these three elements. Preliminary plans are under way to install a soil structure experiment on drainage, with underdrainage and soil structure management as experimental variables, and with the results to be studied on use of the land smoother in direct comparison to other tillage implements. From the same state comes this observation: "It seems to be a truly remarkable situation that we have sufficient data to be sure that tillage and drainage practices are as important in determining yields, as lime and fertilizing practices, yet we are doing four or five times as much work on liming and fertilization as we are on the problems of tillage and drainage."

Texas. In Texas the problem is not that of excess surface water, but of moisture conservation (8). Yet remarkable and interesting is the fact that the identical land-forming jobs required for too much water apply also to too little water. The practice established in Wisconsin of using terraces as interception ditches, then smoothing to surface drain the fields; the Alabama practice of constructing terraces along with smoothing to eliminate erosion, and the Spur (Texas) Experiment Station practice of smoothing and constructing level terraces to catch and retain surface water—all require the same soil management and the same construction machinery to achieve the desired results. The rainfall in the high plains of Texas varies from 11 to 29 in. The primary problem is to conserve a maximum amount of water during the good or wet years to provide sufficient subsoil moisture to bring crops through the dry years. The soil must be made to serve as a water storage.

In studies since 1909 there have been considerable differences in yield produced in the terraced channel compared to that produced in the center of the terrace interval. The usual situation is adequate plant growth in the terraced channel but stunted growth in the center of the terrace interval. In order to determine if more uniform distribution of water between terraces and more uniform plant growth could be obtained, an experiment was designed to change the slope of the land between terraces from the natural grade to level. The areas which were selected had a natural slope between terraces of from 0.5 to 1 percent slope. In some cases the land was leveled between existing terraces, and in other cases parallel terraces were constructed to eliminate point rows and the land was then graded. The entire grading and smoothing job was accomplished with a land smoother handled by a three-plow farm tractor. The cost of the leveling was $14.17 per acre. The experiment was initiated in 1953 and since there was no effective rain in 1954 from the time cotton was planted until it matured, the yields obtained were the result of soil moisture that was stored from rains during the period of October, 1953, to May, 1954. The average yield per acre in 1954 on areas that had not been leveled was 127 lb of lint compared to a yield of 154 lb on the leveled areas. This yield difference amounted to an increased gross return of $8.91 per acre and the increased yield in a single year paid for more than one-half of the land-forming operation. The yields for the 1955

cotton crops were 150 lb of lint per acre on the unleveled areas compared with 238 lb on the leveled sections. The increase was 88 lb to the acre, or an increased gross return per acre of $23.76. This added to the $8.91 increase for the 1954 crop means the cost of $14.17 per acre for the leveling job has paid off more than double during the first two years. The yields were greater in 1955 than in 1954 since rainfall was sufficient to permit supplemental runoff water on the test areas from the land above. The increased production on the leveled areas is due to two causes: *(a)* there were no potholes to drown out and retard the growth and *(b)* the cotton plants each received their correct amount of moisture.

Ohio. In a problem area in Ohio a local technician states that the farmers have found two tools necessary to provide surface drainage. One is the motor patrol to cut the surface ditches, and the other is the land smoother to cover the entire area before the ditches are out, and to distribute the spoil between ditches after they are constructed. The only way they have found to permit water to flow freely to the surface ditches is to fill the minor depressions areas, ranging from one-half inch up to three inches, with land-smoothing equipment. This results in individual row drainage. Another technician in Ohio is in an area where the natural slope of the land is less than 0.10 percent, and with some larger areas having a slope of 0.01 to 0.05 percent. His problems have to do with the following soils and drainage conditions: *(a)* heavy clay soils that do not respond readily to the tile drainage; *(b)* heavy clay soils that respond to tile drainage, but surface drainage is necessary also for good protection from water standing on the land, and *(c)* heavy, silty clay loam soils that respond well to tile drainage.

For condition *(a)*, a systematic surface drainage and land-smoothing program is necessary for crop production and protection. Surface drainage has been found necessary on the untiled land of condition *(b)*, for profitable production and is considered needed on the tiled land as an insurance policy against losses from water standing on the land. The soils of condition *(c)* are the better soils that yield 100 to 125-bu corn crops. However, by careful investigation of some of these tiled fields, it has been noted that there are many small depressions that yield 25 to 50 percent less than adjoining areas. This is found even though the land is tiled at 50-ft spacings. On this type of soil, without tile, the average yield can be raised anywhere from 5 to 20 percent by installing a complete surface drainage and land-smoothing program.

Michigan. In east central Michigan outstanding results have been obtained by combining land smoothing with surface-drainage ditches and also by land smoothing alone. In this area oats and wheat stands have been increased at least 14 percent. By land smoothing alone, the number of plants per acre of row crops such as corn, beans and sugar beets have increased 10 percent. Vastly improved seedbeds, and number of plants per acre, have been observed on legume and grass seedings on those fields combining surface drains and smoothing. On the average, the number of surface ditches has been reduced over 50 percent by land smoothing. On a typical 10-acre field three surface ditches replaced 11 ditches prior to smoothing. Topographic survey before and after smoothing showed some low spots were filled as much as 0.40 ft, and the high spots cut 0.20 ft. After installing surface ditches and land smoothing, this field averaged 58 bu of wheat per acre. Prior to installing the drainage system, the fields averaged 25 bu of wheat per acre. One farmer ran a comparison on two fields being prepared for sugar beets. The same fertilizer and cultural treatment was used on both fields with the smoothed area producing one ton per acre more than the unsmoothed field. In this area it is believed that smoothing should be done before each crop is sown, and that a farmer operating 120-acres or larger can financially justify his own equipment.

Iowa. In Iowa a number of test and demonstration fields have been subjected to either land smoothing alone or surface drains and land smoothing combined. Some work has also been done on smoothing ahead of terrace construction to iron out irregularities caused by rilling on the hillsides, backfurrows and deadfurrows.

Indiana. An area of west central Indiana has many fields of around 1 percent slope with the soil of such nature that on the same field, potholes and erosion are equally important problems. Combining surface ditches to carry off excess surface water for better drainage and construction of cross-slope drainage ditches to control erosion, when finished with land-smoothing equipment, has proved to be a paying proposition. On land where no land smoothing has been done, interception ditches must be spaced closer together in order to remove the surface water. Even with a close ditch spacing, surface-water concentration in deadfurrows has led to serious erosion. In this area farmers have smoothed fields which have ranged from slopes of 0 to 1 percent up to fields having a 10 percent slope.

Illinois. In one section of northeast Illinois most of the soils are heavy clay full of small depressional areas from one to four inches deep, and these depressions hold water long enough to injure plant growth. Technicians in this region feel that smoothing alone will pay for itself by *(a)* eliminating the small puddles that hold water and *(b)* constructing a uniform seedbed. This area has utilized carry-all scrapers to construct the surface ditches and outlets and land smoothers to work the field between ditches. In southern Illinois a large percent of both the bottom lands and the upland hardpan soils are in need of improved surface drainage. Land smoothing goes along with surface drains, and the field personnel recommend it as an integral part of drainage improvement.

Vermont. In the flat, heavy, clay lands adjoining Lake Champlain in Vermont, initial land-forming projects have proven quite successful. These fields are very rough with practically no internal drainage. The solution here seems to be a combination of land smoothing, with drainage terraces or surface ditches. From preliminary results, in which some areas were filled more than six inches, it is apparent that a basic land-forming operation should be spread over a period of two years, with an annual crop between operations. The loose fill can settle and be resmoothed prior to seeding permanent crops.

Humid Area Applications

Actually the humid-area farmer has more extensive application, and more times of the year when he can use land smoothers to his benefit, than does the western farmer who uses his machines for possibly several weeks in the spring and another week in the fall. Farmers in southern Illinois and in Missouri say there are periods during five or six

months of the year when they have operated their levelers.

There are three primary objections raised by people interested in agriculture in the humid areas, who are unfamiliar with land-smoothing and land-forming operations, namely: *(a)* top soil removal, *(b)* soil compaction, and *(c)* cost.

No one can claim, of course, that moving top soil is not harmful, and should not be handled with the greatest of care. There are three points on this subject, however, which deserve consideration. First, top-soil removal has been carefully investigated by research workers during recent years, and results show that fertilization and good soil management can overcome the harmful effects of cutting off the high spots and filling in the low areas. Second, it is not necessary to remove all of the top soil at one time and to expose seeds to clay subsoil. Rather, top soil removal of 2 to 3 inches will produce remarkably beneficial results, and, by good fertilization practices, fertility can be restored within one or two years. This will permit further taking off another few inches in succeeding years to make additional grade corrections. Third, the damage done by top-soil removal is far outweighed by the helpful benefits derived from improved drainage.

Since top-soil removal was particularly questioned in New Jersey and Minnesota, a questionnaire was sent to owners in those areas asking in particular *(a)* how much top soil had been removed, *(b)* if it was harmful to crops, and *(c)* if fertility was restored. The replies received were unanimously favorable. A report received from a vegetable grower in Colgone, N. J., is possibly typical of the results in that general area. The principal crops there are lettuce, sweet potatoes and tomatoes. The smoother was bought originally in 1947 to use for both drainage improvement and tillage application. The leveler is used during periods from March to August every year. The average top soil depth is 8 to 10 in, and some of the cuts have been half of this depth. Soil fertility has been restored by use of both commercial fertilizer and barnyard manure. The top-soil removal has not been harmful to crops where a little has been taken off each year over a period of time.

Farmer replies from south central Minnesota where land-smoothing equipment has been used in land preparation for sugar beets, corn, soybeans, peas, and oats have also been favorable. Small amounts of top soil have been removed each year, over a period of time, and the fertility restored by commercial fertilizers. One of the comments from this area is that in addition to drainage improvement, it has excellent application on spring-plowed ground to conserve moisture. Wojta and Peterson (2) show a gradual over-all year-to-year increase in yields of the terrace channels, where top soil was removed. The addition of commercial fertilizer and organic matter, in combination with the movement of soil during tillage operations, has since improved the fertility and structure of the soil. Heavy offset disk plows were used to penetrate below the top soil and stir up and mix the top 12 in of earth. Thus, even if cuts of two to four inches are made, there is still some fertile soil remaining and the subsoil is loosened up so fertilizer and plant roots will penetrate deeper. In some areas the practice of "stock piling" has been followed. The top soil is taken off and stored, and then replaced and spread after the grade is established by moving the subsoil. This is expensive but does answer the top-soil-removal problem in marginal cases. Another possible answer to excessive top-soil removal might be "bench leveling," in which leveling is done in strips or lands at different elevations across the natural slope. Still another system is to grade alternate strips to a depth below the final surface desired. The top soil in the adjacent paths is then spread over the cut strips to build them back up to grade.

In reference to soil compaction, it is apparent that excessive tillage and working the ground is harmful. Hence, the fewer passes made on a field, with any type of tool, the less the soil will pack. Owners have stated that they eliminate anywhere from two to four passes over their fields with other types of tillage equipment by using land smoothers. A recent study (7) shows that a corn seedbed was prepared at half the cost and half the number of passes over the field with the land smoother than the next most favorable type of tillage operation for seedbed preparation. The fewer passes possible with land-smoothing equipment should, therefore, result in less compaction and less damage to soil structure. In Wisconsin land-forming and land-smoothing operations have been done during the summer or fall when the ground is dry. The ground has then been left smooth, so that the winter and early spring water will drain quickly from the fields. A once-over harrowing in the spring, prior to planting, has resulted in no harmful packing effects. It is wise to deep-chisel or subsoil on many soils after land-forming operations.

Cost is dependent upon many variables. The dirt-moving or land-grading work and the terrace or ditch construction is the expensive portion of land preparation and is done only once, whereas land smoothing is a continuing year-to-year maintenance operation that is comparatively inexpensive and keeps the field from reverting back to its original condition. For the cost of smoothing alone, estimates of anywhere from 50 cents an acre for one time over up to $3.00 an acre for anywhere from three to five passes have been received. When the annual land-smoothing work is considered as part of seedbed preparation, which is true with most farmers, the cost is negligible, since they are pulling the smoother rather than some other tool, and in most cases are actually saving several passes over their fields. The cost, when applied to the complete land-forming job, is entirely a matter of individual field conditions and requirements.

The cost estimates that are available on land shaping show approximately $17 to $50 per acre for combined drainage terraces and land smoothing in Wisconsin, and $45 per acre for precision grading and smoothing in Louisiana. For some of the precision-grading jobs accomplished in the western irrigated states, these costs are small, since improvements of $100 or more per acre are quite frequently made. It is safe to say that the construction of surface ditches and terraces for erosion control constitute the bulk of the expense. The preliminary and final land-smoothing operations are a comparatively small cost of the whole job. On a recent precision-graded test area in Louisiana, 30 percent of the total hours were used for smoothing and finishing. Wisconsin tests several years ago showed the smoothing cost to range from $3.00 to $6.00 per acre with the latter figure including some use of the machine as a scraper.

In this paper it is not suggested or recommended that land smoothing is the cure-all for all soil and water prob-

(Continued on page 410)

Mechanizing Flue-Cured Tobacco Harvest

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Mechanizing the flue-cured tobacco harvest is complicated by the progressive maturing of tobacco leaves and the importance of having undamaged leaves. The seemingly impregnable block to mechanization is not going unchallenged, however, by the supporters of the machine-replaces-hand-labor movement.

THE harvest of flue-cured tobacco is fundamentally different from that of many other agricultural crops since the undamaged leaf is sought and not the seed or other plant parts. Furthermore, leaves are harvested as they ripen from the bottom of the stalk, and it is necessary to go over the field several times to complete the harvest.

At present, flue-cured tobacco is handled many times entirely with hand labor. The lower leaves on a tobacco stalk always mature first, and thus to maintain top quality, they are harvested before successively higher leaves on the plant. As a result, between four to six different primings are usually required, at weekly intervals, to completely harvest or "prime" (as harvesting individual leaves is called) the entire stalk. The primer pulls the bottom ripe leaves (Fig. 1), in each trip through the field (usually two, three or four leaves to each plant). The leaves are held under the arm and placed in a tobacco sled to be transported to a central location, usually near the curing barn. Tobacco from the sled is placed on a table from which handers arrange the tobacco for stringing. The tobacco is tied two to three leaves in a bunch on each side of a tobacco stick. These sticks are eventually hung on tiers in a 16×16×16-ft tobacco curing barn.

Out of the approximately 480 man-hours required to produce an acre of flue-cured tobacco at present, 165 man-hours are required to harvest alone, following the above-mentioned steps.

Table 1 shows how this labor can be broken down into operations, crew, and number of leaf handlings. The conventional practice is to fill one 16×16×16-ft curing barn with about 8,500 lb of green tobacco in one day.

TABLE 1. LABOR REQUIRED TO PUT IN ONE BARN OF TOBACCO (600 STICKS)*

Operations	Crew	No. of leaf handlings Individual	Bulk
Selection and removal of ripe leaves	3 primers (men) 1 mule	1	0
Transporting leaves	1 boy 1 mule	0	1
Positioning of leaves for curing	4 handers (women or older children) 2 stringers (women) 1 handler (woman or older child)	2	1
Placement for curing	Priming crew	0	1
Totals	11 man crew 8 hour day 165 man-hours per acre	3	3

*One priming from about three acres. Approximate value of cured leaf, $460.

Operations Involved

Harvesting can be divided into four separate operations, namely, *(a)* Selection and removal of ripe leaves, *(b)* transporting leaves, *(c)* positioning of leaves for curing, and *(d)* placement for curing.

The first operation requires three primers who handle the leaf one time. The second operation requires one truck or sled driver who transports the leaves in bulk to the curing location. The third operation requires four leaf handers, two stringers, and one stick handler making a total of three times the leaves are handled. The last operation requires the priming crew to handle the leaves on sticks placing them in the barn for curing. This conventional method of harvesting requires, on the average, an 11-man crew to put in a 600-stick barn of tobacco in an eight-hour day. The leaves

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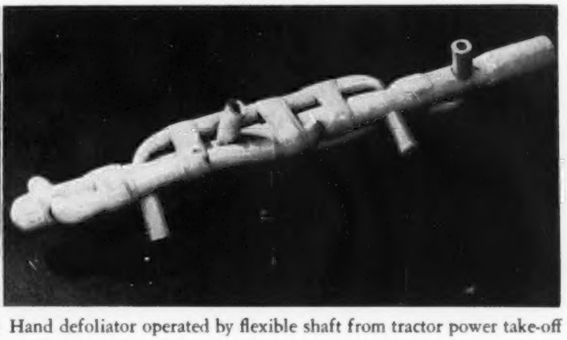

Fig. 1 *(Left)* Conventional method of hand priming • Fig. 2 *(Right)* Hand defoliator operated by flexible shaft from tractor power take-off

are therefore handled individually three separate times and in bulk three different times.

This labor occurs at the time of the year when certain other farm activities must also be carried out on tobacco such as topping, suckering, insect control and curing. Other crops may require some of the labor in this season also.

In the complete mechanization of harvesting, each step may be approached separately and mechanized independently. Thought should be given, however, to eventually combining as many of the separate steps as possible. At the present time only handling of the leaves and their arrangement on sticks for curing have been studied and some worthwhile contributions have been made in the solution of them.

Leaf Selection and Removal

In planning the mechanization of operation, the selection and the removal of the ripe leaves should be considered separately.

In selecting ripe leaves there is no guarantee that adjacent plants will always ripen to the same height at the same time. It is possible, through controlled cultural practices, to improve uniform ripening of tobacco leaves. To do this operation mechanically, it would be desirable to harvest adjacent plants to the same height.

Characteristics of Tobacco Leaves. The mechanized harvesting principles now being used to harvest other field crops do not appear to be suitable for the removal of ripe tobacco leaves. The structure of the tobacco leaf along with other considerations may make necessary a specialized harvesting technique. Although all of the physical characteristics of a tobacco leaf at harvesting time are not known, some known things about the leaf may offer possible solutions.

An average tobacco leaf weighs approximately 0.15 lb and is 18 in long and 12 in wide. It is bruised and torn easily. Tobacco leaves project directly out from the main stalk. The leaves are arranged spirally about the stalk with seven consecutive leaves making up three revolutions of the stalk in most of the common flue-cured tobacco varieties. Because of this factor the leaves do not project radially from the stalk in any set direction. The bud leaves stand fairly erect close to the stalk. As they mature they have a tendency to assume a more or less horizontal position.

The most important physical characteristic of a tobacco plant may be the fact that the leaf breaks free from the stalk at its point of junction with the stalk. At this point the upper fibers of the stem have been put under stress due to the weight of the leaf. As a result very little additional force in a downward direction is required to break the leaf at its juncture with the stalk.

1953 Work. Late in the 1953 harvesting season the removal of leaves by mechanical means was tried. Simple tools were used because of the lateness of the season and no definite conclusions could be made. With the use of tools which would give a downward blow to the stem, it was possible to remove the tobacco leaves from the stalk without any apparent damage to the leaves.

An example of one of the tools used is shown in Fig. 2. The direction of rotation of this unit is such that the portion of the shaft close to the stalk has a downward motion. The ribs strike the leaves projecting out into the row with a downward blow and the fingers strike the leaves in the row with a downward blow. With this simple tool in mind, it

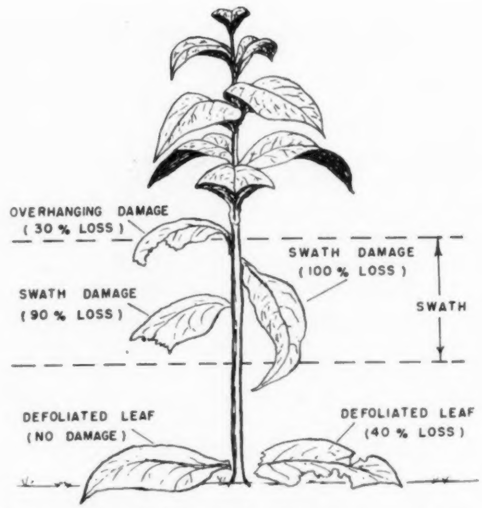

Fig. 3 Example of the type of damage caused by mechanical defoliation

is possible to visualize a complete machine action whereby a unit would be used on both sides of the row.

1954 Work. A high-clearance tractor was constructed for testing various mechanical priming or mechanical defoliating units in the field. Many designs of defoliators were constructed and tried. These units were mounted on the testing tractor so that the leaves on both sides of the row and in line with the row could be removed in the same operation. Various difficulties were encountered such as parting of the leaves, overhanging leaves, sucker growth, and position of the leaves around the stalk.

It was necessary to secure data on the various units and combinations in order to determine the character and causes of damage. The early runs indicated that damage might be more severe in certain positions around the stalk circumference. To check this indication of damage all of the plants (about 240) in the test row were divided individually into four separate horizontal sectors. Assuming the 12 o'clock position of a clock in the horizontal plane was in line with the direction of travel, the first sector was between 11 and 1 o'clock (60 deg), the second between 1 and 5 o'clock (120 deg), and the third between 5 and 7 o'clock (60 deg) and the last between 7 and 11 o'clock (120 deg). Leaves in each segment of the circle were daubed with a different color of water-color paint to permit identification of leaves.

After making a test run, all the leaves and stalks were evaluated for damage. Fig. 3 shows the kinds of damage to a tobacco plant occurring from a defoliating unit. All damage was tabulated as to percent of loss in value per leaf due to damage by the unit. Defoliated leaves from the swath are shown on the ground. These leaves were separated into damaged and undamaged groups. Each damaged leaf was given an index value depending upon the amount of loss in value due to the damage. Most of the leaves left on the plant in the swath were assumed to be totally lost. Some leaves above the swath were damaged also. This damage usually resulted from the leaves overhanging and getting into the unit. Each of these leaves was also given a loss index value.

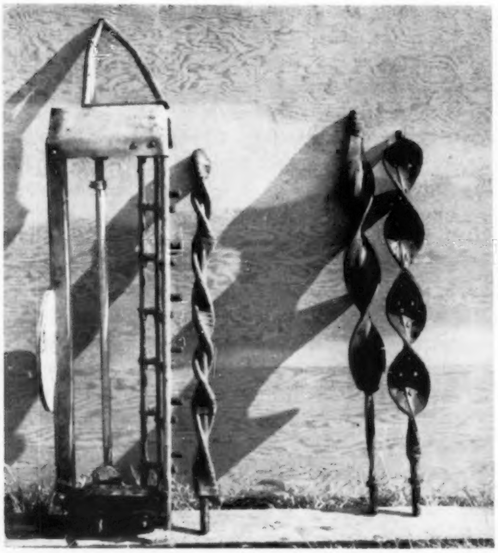

Fig. 4 Finger bar and spirally ribbed units are shown on the left, and a pair of spiral rubber wipers at the right

Fig. 5 Finger bar and spirally ribbed units in defoliating position in field

Thirteen units or unit combinations were tested with varying degrees of success. Many of the units caused losses greater than 10 percent. Fig. 4 shows two of the most promising units. The unit on the left is a combination rubber-covered echelon-mounted finger-bar unit and a spiral rubber-rib unit. The finger-bar unit is made up of three bars with rubber fingers mounted on the bars. The bars move with a roulette motion so that when in operation the removal portions have a downward action along the stalk, the fingers remaining horizontal and pointed out into the row at all times.

Fig. 5 shows this unit in the field. All the units are inclined upwardly at a 20-deg angle with the forward portion being about 15 in higher than the back of the defoliator.

Fig. 6 shows a sample of the damage results secured in two test runs with this unit. These results were secured in the forenoon with a ground speed of 1½ mph and the units rotating at 575 rpm. The sketches show the damage occurring in the four segments of the circle divided up into swath damage only, overhanging damage only, and over-all total damage. The most damage occurred with leaves projecting out from the stalk in line with the row with little damage occurring to the leaves in the 120-deg sectors. The over-all damage from all causes was 5.4 percent in these two runs. With proper shielding the overhanging leaf damage could be reduced or eliminated thereby possibly reducing the losses to 4.1 percent.

The unit on the right in Fig. 4 consists of rubber vanes approximately 2 in wide wound spirally about a shaft. In use this unit acts to wipe the leaves free from the stalk. Fig. 7 shows a sample of the damage results secured in three tests run with this unit. These results were obtained in the forenoon with a ground speed of 1½ mph. The units were operating at 575 rpm. The sketches show the damage obtained in different segments of the circle. Here again the

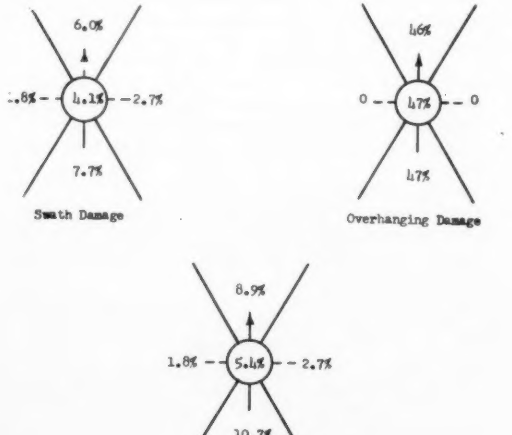

Fig. 6 Percent of damage caused by echelon finger defoliator at 575 rpm during morning operation. Values are average of two test runs, each 240 plants long

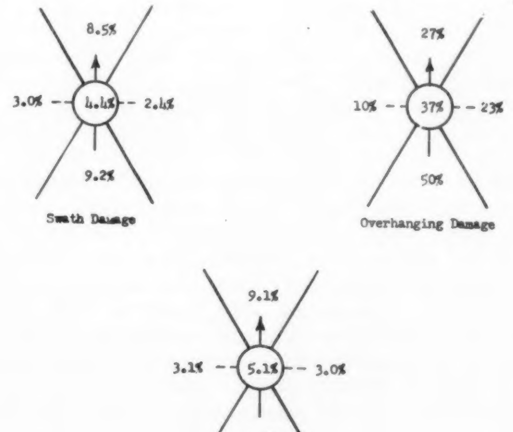

Fig. 7 Percent of damage caused by rubber-wiper defoliator at 425 rpm during morning operation. Values are averages of three test runs, each 240 plants long

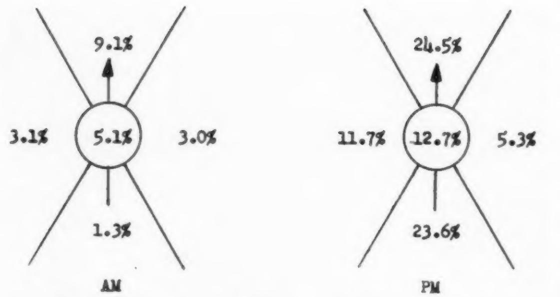

Fig. 8 Damage comparison of morning and afternoon operation with a rubber-wiper defoliator at 425 rpm. Morning operation shows the average of three test runs, while afternoon operation is only one run

majority of damage occurs to the leading and following leaves. Some overhanging damage was noted in the 120-deg segments. Over-all total damage in these three runs was 5.1 percent with 4.4 percent possible if overhanging leaves had been protected.

Less damage occurred in forenoon harvesting operations than in afternoon operations with all units tested. Fig. 8 shows a comparison between forenoon and afternoon operation. On warm dry days the leaves became very limp and were difficult to remove in the afternoon. It may be necessary to confine mechanical harvesting to the forenoon as is desirable with manual priming.

It seems probable that a commercial unit could be developed that would result in defoliation losses of less than 5 percent. Considerable work is still required, however, to perfect these units so that they can be utilized in a complete harvesting machine.

Actual leaf removal may be improved by development of more adaptable varieties of tobacco. Plant characteristics such as leaf internode spacing, shape and positioning of leaves, plant height, and frequency of harvest have a direct bearing on leaf damage in the removal process.

Handling Leaves

After the leaves have been removed from the stalk, the handling of the leaf is of next importance. The problem will be complicated if the leaves fall to the ground as they are removed. It is essential that some means be provided to catch the leaves and transport them to a central location. One possible method of doing this may be by the use of rollers. These rollers would rotate in the opposite direction from the defoliation unit and operate below the unit so that the leaves will fall onto the rollers. The rollers would carry the leaves out to the center of the row to a belt conveyor which would convey them parallel to the row and to a central location on the machine.

Leaf Arrangement for Curing. One of our major problems in tobacco harvesting is the preparation of the leaves for curing. At the present time the technique involves hanging the leaves to both sides of a tobacco stick. Hand stringing is the predominant method. There have been several approaches to securing the leaves to a tobacco stick other than by hand. One common approach has been a mechanical looper which will loop the tobacco similar to conventional manual looping. One manufacturer has been working on a unit for a high-clearance machine so that the individual leaves will be mechanically looped to the stick in the field. This normally would require about four separate leaf handlings. Another quite common method is by means of a clamping arrangement so that the leaves can either be pierced or clamped onto or between sticks.

Another approach that has been made is to use the principle of sewing to attach the tobacco in a more automatic operation. With this approach individual leaves or leaves in bunches will not have to be separated, the leaves can be put on a conveyor and fed directly through the sewing head. The leaves could either be sewed to both sides of a conventional tobacco stick or may even be sewed to a more flexible hanger such as rope or webbing. More uniform drying of the leaf stems may be expected with sewed leaves.

Looking at these various ways of securing the tobacco on a stick, it is possible that a fully developed attaching means can be added to a defoliating machine. In this way the leaves after defoliation can be put automatically in position for hanging in a conventional tobacco barn.

Market Potential

The total production of flue-cured tobacco in the United States is slightly over one million acres. Average allotment per farm is small, however—around 5 acres. The design of a machine should be based upon its weekly capacity for each acre, as each acre must be reharvested weekly for up to six weeks. A machine capable of harvesting three acres per day (one barn of tobacco) could handle around a total of 18 acres per year. It is conceivable that a machine of this capacity could be used cooperatively by more than one operator.

Land Smoothing for Improved Drainage

(Continued from page 406)

lems, or that the other established practices are not necessary. A suitable liming and fertilization program, proper farm and marketing management, adopted crop varieties and other necessary practices found beneficial to the local soil and moisture conditions are all required. It is apparent, however, that the results thus far clearly indicate that land smoothing plus good soil management is better than either one alone. The next and natural step in the over-all agricultural program is to give increased consideration to the land surface itself.

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Heating Drinking Water for Livestock

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COLD weather tends to complicate the problem of providing sufficient drinking water for livestock, especially with respect to preventing ice formation so that an ample supply of water is freely available. An adequate water supply is a fundamental requirement for maximum gains in livestock production. One of the best aids in preventing ice formation on the drinking-water supply in cold weather is automatically controlled heat supplied by electricity. It is convenient to use and is easily controlled.

Agricultural research engineers find little advantage in heating drinking water for livestock in cold weather, except to prevent freezing. Their studies also show that the immersion-type water heater gives most satisfactory all-around performance

Drinking Water Temperatures

The most desirable temperature level of drinking water for livestock was the objective of a series of experiments with hogs carried on for three winters at the Nebraska Agricultural Experiment Station. In these experiments the drinking water temperatures for three separate lots of hogs were maintained at approximately 40F, 55F and 75F, respectively. All other experimental conditions, such as housing, feeding and care, were the same for all lots. A summary of results at the end of three years failed to disclose either significant differences in amounts of water consumed at different temperatures or any definite advantage in amount of gain, rate of growth, or economy of gain. The only reasonable conclusion was that there is no real value in heating drinking water for hogs except to prevent freezing. These conclusions were reported in 1940 (1, 2).*

Another experiment (3), conducted at a small, carefully operated dairy near the Nebraska college of agriculture campus, contributed additional data on the question of optimum drinking water temperature for cows that are giving milk. Water temperature for 12 cows was normally maintained at 40F and was continuously available to all of the cows. For this experiment the temperature of the water was raised to 60F for a period of five days in midwinter. This temperature change definitely increased the consumption of electricity but had no apparent effect on the drinking habits of the cows or upon their milk production. Out of the total of 61.4 kw-hr used for the season, 26.7 kw-hr were consumed during the 5-day period of increased temperature. This was an average of 5.34 kw-hr per day as compared with 0.32 kw-hr per day for the other 109 days of low temperature operation. Outdoor temperatures were not abnormal during the five-day trial period.

The conclusion that there is little to be gained by heating drinking water for livestock, except to prevent freezing, has been reached by others (4, 5).

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*Numbers in parentheses refer to the appended references.

Fig. 1 Experimental water tanks in operation on a roof where they were exposed to outdoor weather conditions. Instruments were located in an adjoining room

Lead Poisoning

A study of the possibility of lead poisoning when using lead-covered heating elements in livestock drinking water has been made in cooperation with the U.S. Department of Agriculture. It was learned that when soil-heating cable of the lead-sheathed type is operated in well water at average hardness, a protective coating is formed on the lead surface and tends to prevent the lead from going into solution. Most of the lead given off by newly installed cable goes into solution during the first 24 hours of operation, during which time the protective coating begins to form. As a matter of precaution, it is well to drain the tank and refill with fresh water after operating the lead-cable heater for about 24 hours.

Rain water, soft water or water tending to be acid would be unsafe for use with lead-covered heating cable. Only small traces of lead were found when the cable was used in water having a total hardness equal to 80 parts per million of calcium carbonate. Above this level it was considered safe to use lead-covered heating units.

Electrically Warmed Stock Tanks

Three heat-conserving factors which seemed most practical in electrically warmed stock tanks were selected for test. They were *(a)* a tank cover made of wood, *(b)* insulation around the tank, and *(c)* a bottomless wooden heat-retaining box surrounding the heating element to confine heat to a drinking opening.

Five small round steel tanks 3 ft in diameter and 2 ft high, each provided with a different means of conserving heat, were operated under outdoor winter conditions, Fig. 1. All tanks were equipped with identical thermostatically controlled floating-type tank heaters designed to keep a drinking opening free of ice. The first tank had only the floating heater and was not supplied with any additional heat-saving equipment. The second tank had the heater and

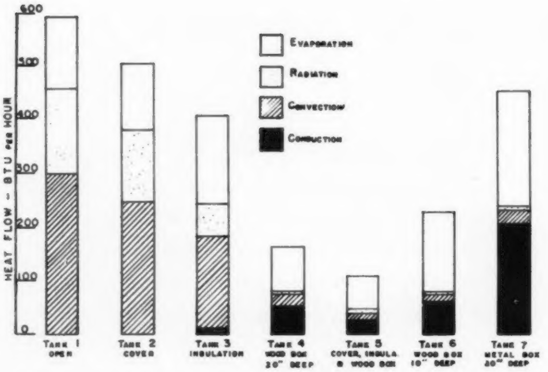

Fig. 2 Relationship of heat losses from experimental tanks by evaporation, radiation, convection and conduction

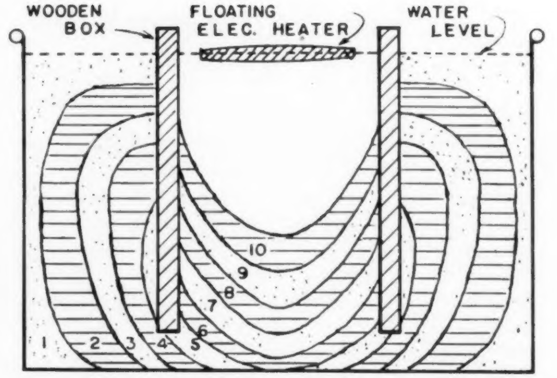

Fig. 3 Typical pattern of daily ice formation at 5 F in an electrically heated experimental stock-watering tank. Numbers indicate daily accumulations of ice which were approximately stabilized after 10 days. Electric-energy requirements did not vary greatly after stabilization

one heat-conserving feature, a close-fitting wooden cover 1½ in thick (two layers of common 1-in lumber). The third had the heater and four inches of insulation around the sides — nothing else. The fourth was equipped with only the bottomless heat-retaining wooden box in addition to the heater, and the fifth tank had the heater plus all three economy features—cover, insulation and heat-retaining box.

Heat Losses

Heat losses by evaporation from the surface of the water, radiation and convection from the water surface and from the sides of the tank, and conduction through the insulation around the tank and through the wooden box were computed from the data taken for each tank by standard formulas, Fig. 2.

The open tank, which had none of the heat-conserving features, was used as a basis for comparisons. The heat losses of this tank averaged 594.3 Btu per hr. The tank that ranked highest in economy of operation was the one having all of the heat-conserving features. The average loss for this tank was 108.0 Btu per hr. As compared with the open tank, this combination of three features saved 81.8 percent of the electricity used by the open tank. Second best was the tank having only the wooden heat-retaining box. It lost only 162.0 Btu per hr, making a saving of 72.7 percent. Third in economy was the tank having insulation around the sides. It lost 403.8 Btu per hr, saving 32.0 percent as compared with the open tank. The wooden cover alone saved 15.1 percent, the heat losses averaging 504.7 Btu per hour.

Wooden Heat-Retaining Box

The best single heat-conserving feature, the bottomless wooden heat-retaining box, was 1½ in thick and made of two layers of 1-in white pine. It was 13 in square inside, and 21 in deep, extending 20 in below the surface of the water to within about 3 in of the bottom of the tank. Wet wood is not considered a good heat-insulating material, but the wooden box was an effective barrier between ice-free water inside the box and solid ice much of the time outside the box. Water circulated freely through the open bottom.

Tests were also made in a single tank under controlled conditions. These were used to determine the effects of *(a)* constructing the heat-retaining box of metal, *(b)* changing the dimensions of the box, *(c)* changing the location of the heating element, and *(d)* use of the heat lamp. Ambient temperature was maintained at approximately 5F to accelerate heat losses and permit each test to be completed within a two-week period. Ice formation was similar for each test (Fig. 3) and the test conditions could be readily repeated.

A galvanized-iron box of the same inside dimensions as the wooden box was nearly 2.8 times as wasteful of heat, the loss being 450.7 Btu per hr as compared with 162 Btu per hr for the wooden box. The metal box was somewhat better than the open tank which lost 504.7 Btu per hr. The saving effected by the metal box over the open tank was 24.2 percent.

TABLE TO SUMMARY

	Tank 1*	Tank 2†	Tank 3‡	Tank 4§	Tank 5‖	Tank 6#	Tank 7**
Heat loss (Btu per hr)	594.30	504.70	403.80	162.00	108.00	227.40	450.70
Heat used (percent)	100.00	84.90	68.00	27.30	18.20	38.30	75.80
Heat saved (percent)	0.00	15.10	32.00	72.70	81.80	61.70	24.20
Electricity used per day (kw-hr)††	4.18	3.55	2.84	1.14	0.76	1.60	3.17
Operating cost (cents per day)‡‡	10.45	8.88	7.10	2.85	1.90	4.00	7.93

*Open—control or "check" with heater only; no other heat—conserving features.
†Cover—heating plus double-thickness inch-board cover on tank.
‡Insulation—heater plus 4 in insulation (shredded redwood bark) around tank.
§Wood box, 20 in deep—heater plus double-thickness inch-board box around drinking opening, 13 x 13 x 20 in deep.
‖All—heater plus cover, insulation, and wooden box 13x13x20 in deep.
#Wood box, 10 in deep—heater plus double-thickness wooden box 13x13x10 in deep.
**Metal box, 20 in deep—heater plus galvanized iron box 13x13 in inside and 20 in deep.
††Maximum use—no animals drinking and no inflow of warmer well water.
‡‡At 2½ cents per kw-hr.

Changing the vertical dimension of the bottomless wooden box had little effect on heat loss until depth of immersion in the water was reduced to about 10 in. A sharp rise in heat loss was recorded for this depth, the average loss being 227.4 Btu per hr. The increase, as compared with the average loss of 162 Btu per hr for the 20-in depth, was a little more than 40 percent. Increasing the lateral dimensions of the box, making a larger drinking area, tended to definitely increase heat loss by radiation, convection and evaporation from the greater water surface.

Placing the heating element 20 in below the surface of the water resulted in no important change in average heat loss as compared with placing the source of heat at the water surface. The difference was less than 2 percent in favor of the floating heater. Since the float, to which the heating element was attached, reduced the amount of water-surface area exposed to cold air, there was less loss of heat. This seems to be a good but not highly important design feature.

Heat Lamp

A 250-watt heat lamp of the hard-glass type, thermostatically controlled, was effective in preventing ice formation on the drinking area within the open-top wooden box. Operating costs, however, were more than double those for the immersion-type heating units used under similar conditions. Thermostat control was effective when the height of lamp above the water surface was less than 24 in, but the lamp remained "on" continuously at heights greater than this. Ice formation was prevented, however, at lamp heights below 42 in. Air temperature was near 5F during these observations.

Costs of operation which are computed from all tests are maximum since no animals were drinking from the tanks and, therefore, no replacement water was used. Since water from wells is usually warmer than the 40F average temperature maintained in the tanks, some heat is normally added from this source, requiring less auxiliary heat. The cost of operation decreases with increasing numbers of animals drinking.

Summary

1 Little advantage was found in heating drinking water for livestock except to prevent freezing.

2 Lead poisoning from lead-covered soil-heating cable was negligible after 24 hrs use in water having a total hardness equal to 80 parts per million or more of calcium carbonate. Rain water, soft water or water tending to be acid would be unsafe at any time for use with a lead-covered heating element.

3 Three methods of conserving heat in an open electrically heated stock-watering tank effected substantial savings in operating cost as follows:

	Percent savings
(a) Wooden cover, 1½ in thick	15.1
(b) Four inches of insulation (K value approximately 0.3) around the outside of the tank	32.0
(c) Open-bottom wooden box with sides 1½ in thick enclosing the drinking opening	72.0
(d) Combination of *(a)*, *(b)* and (c)	81.8

4 An electric floating-type immersion heater in which the float itself covered part of the exposed water surface provided limited economy of operation (about 2 percent) as compared with placing the heating element 20 in below the water surface.

5 Infrared lamps (inexpensive and easy to install) prevented ice formation at distances less than 42 in from the water surface, but cost of operation was more than doubled for results comparable with immersion-type heaters.

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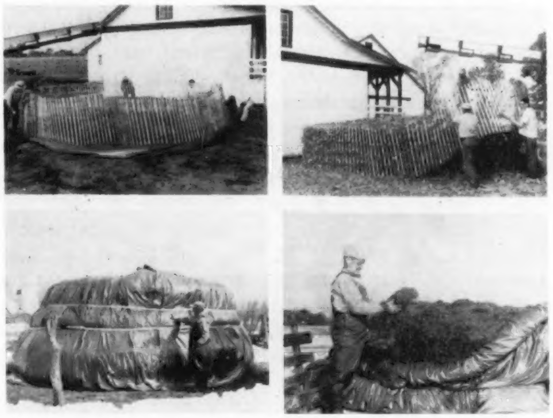
Plastic Silos

SILAGE can now be stored in convenient spots around the farm in plastic silos. These silos consist of large, open-ended sleeves made of plastic, 0.008-in thick, in two sizes—22 ft long and 55 ft in circumference designed to hold 35 tons, and 27 ft long and 63 ft in circumference to hold 70 tons. The plastic used is resistant to mold and water and has low oxygen permeability. Rolled down like a stocking, the sleeve is spread on the ground in a ring, with the bottom end of the sleeve drawn in toward the center to make an air-tight base when weighted down with silage. A strip of snow fence, set up just inside the silo ring, forms a



circular enclosure *(top left)*. Silage, mixed with a preservative, is distributed evenly and packed tightly by stomping. When the bottom layer is filled, the snow fence is removed and set up again on top of the layer *(top right)* but with the diameter reduced. Three or four layers can be stacked. The plastic film is then rolled up the sides, gathered together at the top, and tied. Gases produced by the fermenting silage slowly inflate the bag and, after about 96 hours, are allowed to escape so that the film settles back around the stack.

In October, 1955, a farmer in Asbury Park, N. J., stored 33 tons of alfalfa mixed with corn-cob meal in one of the new silos *(bottom left)*. Opened after more than six months, it is reported that the silo had preserved all but about 25 lb *(bottom right)*.—Product is manufactured by the Bakelite Co., a Division of Union Carbide and Carbon Company.

Preventing Crop Losses by Drying

Carl W. Hall
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Heated-air and unheated-air crop-drying methods are compared and evaluated in this paper with respect to benefits gained through prevention of crop losses.

SEVERAL methods of determining the value of crop drying have been used. Some of the advantages and disadvantages are difficult to evaluate economically. Data recently released in a U. S. Department of Agriculture publication provide a basis for evaluating crop-drying benefits on the basis of preventing losses(6)*. These data present the losses which occur in the various phases of production on the basis of the percent of production, the number of acres represented by the loss, and the value in dollars of the loss for various farm crops throughout the United States.

The following three methods could be used to evaluate losses for a particular farm:

- The percentage loss could be established for a certain size of farm. This method would be difficult to apply to a particular farm because of the diversity of the number and acreage of various crops grown on other farms of the same size.
- The loss could be established on the basis of the value in dollars for each acre of a crop produced. This method would not be applicable because the quantity of production of crops per acre varies greatly from one farm to another.
- The losses could be compared on the basis of the loss in dollars for each bushel of a crop produced. This method of determining the importance of losses for an individual farmer would be the most applicable. A farmer has a reasonably good idea of the number of bushels of various crops produced on his farm and from this can estimate the loss each year from the various crops (Table 1).

TABLE 1. ANNUAL LOSS OF FARM CROPS IN THE UNITED STATES, 1942-51 (6)

Crop	Actual net annual production, 1,000 units	Annual value, $1000	Value of loss, $1,000: During harvest	During storage	From insects	Total	Loss per unit of production
Corn, bu	3,036,380	4,146,062	$172,753	$168,172	$ 3,682	$344,607	$ 0.114/bu.
Cereals*, bu	2,812,342	3,445,762	181,356	89,666	13,111	284,133	0.101/bu.
Hay, ton	102,296	2,088,144	555,076	99,362	0	654,438	6.40/ton

*wheat, oats, barley, rice.

Grain Loss

About 10 percent of the grain raised on farms never reaches market or the place of intended use because of losses during harvesting and farm storage. Harvesting losses are caused by *(a)* wind damage, *(b)* lodging, *(c)* shattering by rain, *(d)* insect damage in the field, and *(e)* improper adjustment of the machinery. Some of these losses can be eliminated almost entirely by harvesting at the proper time followed by drying the grain with mechanical ventilation. Storage losses of grain are caused by *(a)* growth of the mold, *(b)* heat produced by the mold, *(c)* the effect of foreign material, and *(d)* insects. The loss from insects is listed separately in Table 1. These losses can be prevented by mechanical ventilation of the grain storage. Insect damage to grain in storage was due to various weevil, borer, moth and beetle which fed on the grain and caused local heating with subsequent formation of moisture which produced surface crusting and spoiling. Most of this loss can be prevented by mechanical ventilation of the grain.

Hay Loss

About 28 percent of the field hay crop never reaches market or its intended use because of loss. Field losses consist primarily of shattered leaves and rain damage which can be greatly reduced by mow curing. Storage losses are principally the result of excess moisture in hay which causes increased microbial activity resulting in mold damage and heating. Storage losses in hay can be reduced by a properly designed and managed mow-curing system.

Loss Reduction

How much of the loss can be prevented? Field losses during harvest of grain can be reduced considerably by early harvest. When early harvest is practiced, the grain is at a higher moisture content than during normal harvest. Harvesting losses increase with delayed harvest of corn. In Indiana in 1952, on November 2 there was approximately 10 percent loss of the total yield during harvest as compared to a 24 percent loss on December 7. The loose ear loss on December 7 was 4.5 percent as compared to zero on November 2(2). Minimum field losses of corn will occur when the moisture content is between 24 and 30 percent (4). For a picker-sheller the total field loss was approximately 10 percent of the gross yield for corn from 24 to 30 percent moisture and went up to 22 percent loss for corn at 20 percent moisture. A method of drying is required to assure safe storage after harvesting at high moisture. The saving of corn obtained by prevention of field losses only will seldom be of sufficient value to equal the additional drying costs, except for high yields above 125 bu per acre(4). From these data it appears that approximately 55 percent of the normal harvest loss can be saved.

The loss of wheat during harvesting can be reduced by early harvest. In Ohio minimum losses of wheat per acre,

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*Numbers in parentheses refer to the appended references.

including shattering loss, occurs at about 18 percent moisture and amounts to a reduction from the normal loss of 2 percent to 1 percent of the expected loss(5). A properly adjusted combine will function satisfactorily for high-moisture wheat. Harvesting at a higher moisture content would necessitate drying of the combined product. Also, it was found that there was an increase in the test weight of wheat harvested at 18 percent.

Considerable loss of hay occurs when it is cured in the field. Field losses of hay during harvest can be reduced considerably by handling the hay at a high moisture content. There are two major field losses which can be reduced: weathering and mechanical leaf loss. Field-dried hay is normally at 25 to 28 percent moisture content before it is moved to the mow. The loss incurred during handling because of leaf loss is considerable as the moisture content is reduced to 30 percent. Leaf loss of alfalfa was from 10 to 65 percent for a moisture range of 28 to 32 percent(7). It is important that leaf loss be reduced because the leaves in alfalfa hay make up 50 percent by weight and contain 70 percent of the protein(1). During field curing of hay a loss of 22 percent of the dry matter occurred as compared to a loss of 7.5 percent of the dry matter by artificial drying(1). A reduction in the loss of dry matter during harvest of approximately 65 percent can be obtained.

The exact saving which can be secured in storage is difficult to assay. However, it seems quite reasonable that approximately 95 percent of the storage losses of grain and hay could be prevented through proper storage and mechanical ventilation. Possible savings of 70 percent of the total losses of grain and hay which occur during harvesting and storage could be made by a combination of early harvest and drying. The saving, which could be evaluated in terms of financial returns, would be approximately 8 cents per bushel for corn and wheat and \$4.48 per ton for hay, based on Table 1. Thus, for a production of 1,000 bu of grain and 50 ton of hay, a gross saving of approximately \$80 for the grain and \$224 for the hay, making a total of \$304, could be attributed to early harvest and drying.

TABLE 2. OPERATING COST OF DRYING

Quantity after dried	Crop	Moisture range percent	Water removed, lb	Operating cost Heated air, 50¢/100 lb water	Operating cost Forced air, 30¢/100 lb water
1 bu	corn	26 to 16	7.5	\$0.0375	\$0.0225
1 bu	wheat	20 to 15	3.8	0.019	0.0114
1 ton	hay	40 to 20	667	3.33	2.00

The cost of additional equipment and other items to provide this saving can be evaluated. Slightly more power would be required for combining wheat at the higher moisture content. Data are not available to evaluate this cost. The fixed and operating costs of the drying equipment must be considered. The annual fixed cost for a heated-air system is from 13 to 14 percent of the initial cost and for an unheated forced-air system is 9 percent of the original cost(3). The operating costs are approximately 50¢ for each 100 lb of water removed by heated air and from 15 to 30¢ per 100 lb of water removed by unheated forced air. The cost of operation for the unheated forced-air system covers a wide range because its efficiency is greatly dependent on the weather.

The operating cost of removing 10 percent water from corn, 5 percent from wheat and 20 percent from hay is shown in Table 2 for 1 bu of corn, 1 bu of wheat and 1 ton of hay.

The annual fixed cost for a heated-air system costing \$2500 is 2500×13 percent = \$325, and for a forced-air system costing \$700 is 700×9 percent = \$63. The annual fixed cost is added to the operating cost to get the total cost. Following is a sample calculation for 500 bu corn, 500 bu wheat, and 50 tons of hay with one installation:

Operating cost:		Operating cost:	
Corn	\$18.75	Corn	\$11.25
Wheat	9.50	Wheat	5.70
Hay	166.50	Hay	100.00
Total	\$194.75	Total	116.95
Fixed cost	325.00	Fixed cost	63.00
Total Cost (heated air)	\$519.75	Total cost (unheated air)	\$179.95

The total gross saving previously calculated, which could reasonably be expected for the above example, is \$304. Thus the heated air system would not be economical on the basis of these potential savings. The unheated air system would be economical *if* the speed of operation is not important and the weather is favorable for drying. Similar comparisons can be made with other acreages and with other crops.

These figures do not include the possibility of total loss of product, which can occur in any one year, although the average figures used for determining the loss would take it into consideration. The economic value of early harvest to permit another crop is not included. The saving of hay is often large enough to pay for a forced-air system of drying in one year. The greatest potential for preventing losses is by mow drying of hay, which does not usually appear as a direct cash increase to the farmer because much of the hay is fed on the farm. By doing custom drying the purchase of a piece of heated-air equipment could be justified economically on a small farm. Maintaining nearly the original feed value of the product is an inherent advantage and would add to the value of a drying system. The advantage of controlled rapid drying with a heated-air system is not considered and would be important in many situations. The additional value of the crop after an extended storage period should be credited to paying for the building and drying system. If the grade is maintained the value of grain will often increase 15 to 25 cents per bushel and hay 2 to 5 dollars per ton during the storage season.

Based on the moisture which would normally need to be removed to prevent the losses on the farm, the value of saving would be approximately 0.8¢ per lb of water to be removed. This value was used for Fig. 1. By comparing the

(Continued on page 421)

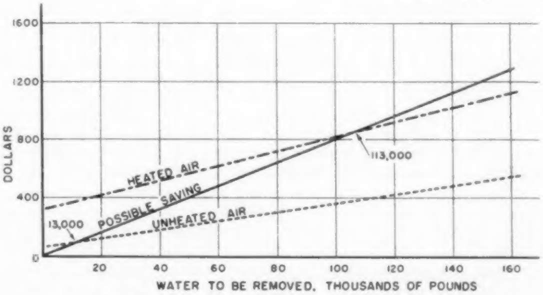

Fig. 1 Cost of drying compared to saving from losses only

Linear Programming—A Tool in Engineering

Myron Tribus and Alan J. Rowe

Recognizing that engineering problems are primarily problems of "synthesis" as opposed to "analysis" and their solutions therefore often highly complicated, the authors in this paper present a mathematical procedure, known as "linear programming," for arriving at optimal solutions of actual problems

WHILE there have been many attempts at defining engineers and the engineering profession, there has been considerably less attention paid to defining engineering *problems*. In recent years all fields of engineering, from agricultural through the rest of the alphabet, have become more "scientific", that is, have used methods of analysis based on fundamental laws and fewer blind empiricisms than heretofore. The successes of some persons with purely scientific outlook and training in analyzing some phases of engineering problems have served to obscure the essential difference between problems in engineering and science. Yet there is one essential difference which serves to define engineering problems very clearly. The world of science has no room for the application of value judgments—the solution to a scientific problem is neither "good" nor "bad". It is merely "correct" or "incorrect". An engineering solution is either "good", "bad" or "indifferent" depending upon the society, time and circumstances.

Engineering problems can be defined more closely by using the language of mathematics. Some of the characteristics of an engineering problem are:

- The problems are combinatorial, that is, one is seeking the proper combination of
  1 Energy, 2 Materials, 3 Land, 4 Time
- There are always more unknowns than there are equations. (If there were no degrees of freedom, only one solution would work.)
- The restrictions on the variables occur as inequalities, *i.e.,* the Second Law of Thermodynamics, rupture strength of metals, pH limitations in soils, etc.
- There is some "value function" (usually "profit" or "cost") to be maximized or minimized.

Engineering problems are thus primarily problems of *synthesis* as opposed to most problems in science which are usually problems in *analysis**. Problems in analysis may be stated, "Given such and such a system, how does it perform?" whereas problems in synthesis pose the question "Of all possible systems, which is best?" Synthesis is harder than analysis because synethesis requires *analysis plus value judgment plus selection.*

Engineering problems are difficult for two major reasons.

Sometimes the "profit" or "value" function is not understood or agreed upon. Haziness in being able to discriminate between "good" and "not so good" solutions does not always make a task tough, however. On the contrary, lack of good criteria of value makes it easier for the incompetent to contribute. Witness, for example, the junk sold as kitchenware throughout the country.

Even when the "value" functions are very well defined, as they are, for example, in certain limited activities of a capitalistic economy (where the goal is "maximize profits"), an engineering problem is still likely to be difficult. Only in a certain limited number of these rare well-defined problems do we have methods for synthesizing an "optimum" solution.

One of the methods for finding an optimum is called "linear programming" and the purpose of this paper is to give an introduction to the ideas and methods of linear programming. We have drawn freely upon a number of published articles and make no pretense at mathematical rigor. Instead, we hope to present the essential ideas in a simple fashion, accessible to the average engineer and without the need for a strong mathematical background. We appreciate that someone who wishes to utilize the method will find it necessary to study material beyond that of this paper.

The examples we give are purposely chosen to be simple enough that the solutions are almost obvious. The reader should appreciate, however, that the methods of linear programming have been applied to problems involving several hundreds of variables, and in such cases no other methods now appear to be practical.

A Linear Programming Example

In business and engineering, problems which can be formulated in terms of linear programming often arise where limited resources have to be distributed among competing demands. These problems give rise to a set of interdependent activities, and many alternative solutions. The problem is to determine at what level these activities should be performed in order to achieve some quantitatively expressed objective. Such a solution of the problem is called an optimum solution. In general, there are many feasible solutions to an actual problem, but only one or a few are optimal. The optimal solution is reached by linear programming.

As a typical linear programming problem, assume that a merchant has on hand 140 gal of vanilla ice cream, 100 gal of chocolate, and 120 gal of strawberry. He can sell the ice cream in five different ways as follows:

	Selling price per gal	Cost per gal	Profit per gal
Vanilla, plain	$1.20	$.70	$.50
Chocolate, plain	1.25	.75	.50
Strawberry, plain	1.30	.80	.50
Vanilla-chocolate mixture (50 percent—50 percent)	1.35	.80	.55
Vanilla-strawberry mixture (50 percent—50 percent)	1.40	.85	.55

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill, December, 1955, on a program arranged by the Farm Structures Division.

The authors—MYRON TRIBUS and ALAN J. ROWE—are, respectively, associate professor of engineering, University of California (Los Angeles), and consultant, manufacturing services, General Electric Co.

*The authors exclude, of course, certain problems in pure chemistry and genetics, for example. But even these activities are often carried on in order to *analyze* scientific methods.

How should the merchant sell the ice cream such that his profit shall be a maximum? (It is to be noted that the mixing operation adds to the cost.) The problem can be restated in the following manner, defining a set of variables:

X_1, number of gallons of vanilla sold	. . . . .	[1]
X_2, " " " " chocolate sold	. . . .	[2]
X_3, " " " " strawberry sold	. . . .	[3]
X_4, " " " " first mixture sold	. . .	[4]
X_5, " " " " second mixture sold	. . .	[5]

The following equations indicate that relationship between all possible uses of each ice cream and the available amount:

$140 = X_1 + \quad .5X_4 + .5X_5$ (total gallons of vanilla) . [6]

$100 = \quad X_2 + \quad .5X_4$ (total gallons of chocolate) [7]

$120 = \quad X_3 + \quad .5X_5$ (total gallons of strawberry) [8]

$0 \leqq X_i \; i = 1, 2, \ldots, 5$ . . . . [9]

and the profit from this venture can be expressed as

$Z = .5X_1 + .5X_2 + .5X_3 + .55X_4 + .55X_5$ . . . . [10]

The problem of the merchant has been formulated in terms of five variables (unknowns) which can take on only positive values, four inequalities and one linear function, Z, the maximum value of which has to be determined. Since there are more unknowns than equation, the question is how to find the value of each unknown which will maximize the profit function, Z. This is a typical "linear programming" problem. The characteristic features of these problems are:

- All equations are linear.
- All variables are restricted to positive values.
- More unknowns than equations.

If the number of independent equations were equal to the number of unknowns, there would be only one solution. Where there are more unknowns than equations, there is an opportunity to maximize Z by changing the values of the unknowns until a maximum is attained.

While a solution of the particular problem shown here can easily be reached by inspection, it will be solved by a linear-programming method known as the "simplex method," in order to illustrate the technique which can be applied to more complex problems.

An initial feasible solution to the merchant's problem is indicated in Table 1, and following is the interpretation of the equations given:

Table 1.

140 =	X_1			$.5X_4$	$5X_5$	(11)
100 =		X_2		$.5X_4$		(12)
120 =			X_3		$.5X_5$	(13)
Z - 180 =				$.05X_4$	$.05X_5$	(14)

1 The table shows a "basic feasible" solution since it satisfies the equations but does not necessarily maximize Z. This solution is $X_1 = 140$, $X_2 = 100$, and $X_4 = X_5 = 0$. The values for Z are obtained by eliminating the variables in the original set of equations from the original Z equation, as follows:

(a) Add the three equations [6], [7], and [8] which results in
$360 = X_1 + X_2 + X_3 + X_4 + X_5$ . . . . . . [15]

(b) Eliminate X_1, X_2, X_3 from
$Z = .5X_1 + .5X_2 + .5X_3 + .55X_4 + .55X_5$, which gives
$Z\text{-}180 = .05X_4 + .05X_5$ . . . . [16]

This result is shown as equation [14] in Table 1.

2 The values of Z in equation [14] indicate the relative profits that could occur if X_4 or X_5 are introduced into the solution.

The problem now is whether there is a better solution. Refer equation [14], it can be seen that the relative profit for selling either X_4 or X_5 is 5 cents. Thus Z can be increased by introducing one of these variables and removing one of the variables in the current solution (X_1, X_2, and X_3). We will proceed by bringing X_4 into the solution.

The maximum amount of X_4 which can be brought into the solution is determined by the ratio of the numbers in the first column of Table 1 to those in the X_4 column, *e.g.*, 140/.5 and 100/.5. The smallest of these ratios is the limiting factor. We cannot bring in more of X_4 because the larger value will cause one of the variables to become negative, a physically impossible value (see equation [9]). The coefficient of X_4 which corresponds to this smallest ratio is circled in the basis equation [12], and is called the "pivot" element.

Linear-programming problems thus differ from the usual maximization problems solved in engineering because the maximum is not found through differentiation. Straight lines do not have maxima inside their limits. Similarly, linear equations (sums of straight lines) can have no local maxima. When a variable is changed, it must either be decreased to zero or increased to a point where some other variable has been forced (by the equations) to go to zero.

The next step is to make the pivot element equal to unity by multiplying the entire equation by an appropriate factor; in this case 2. This new equation is then written in the next table as equation [18]. Therefore, we proceed by bringing in one variable and removing one variable from the basis, (Thus always maintaining the number of variables in the solution equal to the number of equations). This amounts to exchanging one variable for another. When the X_4 variable is introduced into the solution, some of the other variables in the solution are modified. These changes are a result of the elimination procedure. The pivot element in the solution always has a coefficient of unity and the remaining values in that column are reduced to zero by elimination.

For example, X_4 is eliminated from (11) as follows:

$140 = X_1 + .5X_4 + .5X_5$	
$100 = X_2 + .5X_4$	multiply by -1 and add.
$40 = X_1 - X_2 + .5X_5$	new equation [11] which is shown as equation [17] in Table 2.

The same kind of elimination is done to obtain equations [19] and [20]. These results are tabulated and yield the improved solution in Table 2. Note that equation [19] remained unchanged since it had no coefficient in the column under X_4 to be eliminated.

Table 2 has been changed slightly to make it easier to read. The variables have been listed above the columns and only the coefficients are shown in the body of table. Also, X_4 has been interchanged with X_2 so that the first three columns indicate the variables in the solution.

An examination of equation [20] in Table 2 shows that bringing X_5 into the solution would increase the value of Z.

Table 2.

Value		X_1	X_4	X_3	X_2	X_5	
40	=	1			-1	.5	(17)
200	=		1		2		(18)
120	=			1		.5	(19)
Z - 190	=				-.1	.05	(20)
						in	

Therefore, this has an arrow labeled "in" under the $X5$ column. As before, the amount of X_5 which can be brought into the solution is limited by the smallest ratio, *e.g.,* 40/5 and the .5 in equation [17] is circled and becomes the pivot element. Multiplying equation [17] by 2 yields equation [21] in Table 3. The other equations are obtained by elimination in the same manner as for Table 2. The results are shown in Table 3.

A further change has been made in the arrangement of Table 3. Rather than shift the variables in the solution each time, a new column is added which indicates the variables currently in the solution. This arrangement of the equations will be used in the subsequent problems.

Equations [21] and [24] represent an optimum solution for this problem since all relative profits are zero or negative. This means that no further change of the basic variables will increase profits. In order to show this, introduce X_1 and observe that profits would decrease ten cents per gallon. The solution has the interpretation that the profit is $194 when 80 gal of vanilla-strawberry; 200 gal of vanilla-chocolate, and 80 gal of plain strawberry are sold. In this solution all the ice cream is sold in the proportions indicated.

"Optimal solutions" to linear-programming problems have certain features, as follows:

(a) If there are m unknowns and n equations, *at least m-n of the unknowns will be zeros.*

(b) All the coefficients in the equation will be negative or zero, when Z is a maximum. (However, if Z is to be minimized, the coefficients will be all positive or zero.)

"Basic solutions" such as shown in Tables 1, 2, and 3 are characterized by the fact that each variable "in the basis" appears in only one equation. When a new variable is brought "into the basis," the various equations must be

Table 3.

Variable in basis	Value	X_1	X_2	X_3	X_4	X_5	
X_5	80	2	-2			1	(21)
X_4	200		2		1		(22)
X_3	80	-1	1	1			(23)
	Z-194	-.1					(24)

added or subtracted from one another to keep the characteristic feature that each basic variable occurs in only one equation. This arrangement of the basic variable is known as the canonical form.

Because of the way the calculations are performed (always introducing the most profitable variable), it should be clear that each new table produces an improved solution. *Since the equations are all linear (and Z varies linearly with each X), it pays to increase the profitable X as much as possible which means that no intermediate maxima exist.* This can be explained by the fact that the maximum value for a "line" is at one of the two end points. Thus the maximum profit could not exist along the line, but must be at an extreme point.

The following characteristics are given without a formal proof:

(a) If a maximum value of Z is found, it is the largest value possible. It is not a local maximum. (This feature follows from linearity.)

(b) The maximum will generally be found in a finite number of steps.

A variation on this problem is given in the book "An Introduction to Linear Programming."†

A Second Linear Programming Example‡

Suppose a manufacturer is making products P_1 and P_2 which requires the use of three screw machines (s_1, s_2, s_3) as well as two grinders (g_1 and g_2). Each of the products must first be processed on a screw machine and then on a grinder. The screw machines differ in capacity and the surface produced on the work piece. Thus depending upon which screw machine is used, a different amount of grinding must be done.

Suppose that the manufacturer has data available on the time it takes for each machine to carry on its process. Production processes 1, 2, 3, . . . , 12 will be considered as represented by Table 4 (times to produce one thousand parts (hours) by different processes).

Each machine is available only 40 hr per week. The manufacturer receives a profit of $1.00 per thousand on

Table 4.

Machines	Production of P_1						Production of P_2					
	1	2	3	4	5	6	7	8	9	10	11	12
s_1	2.00			2.00			3.00			3.00		
s_2		5.00			5.00			7.50			7.50	
s_3			4.00			4.00			6.00			6.00
g_1	0.50	0.10	0.20				1.00	0.20	0.40			
g_2				0.40	0.10	0.15				0.80	0.20	0.30

†Charnes, A., Cooper, W. W., and Henderson, A. An Introduction to Linear Programming. John Wiley and Sons, 1953, pp. 2 to 15.

‡Similar worked examples are given in ASME preprint 54-A-223, application of linear programming to production engineering and scheduling, by E. Leonard Arnoff, 1954.

item P_1 and a profit of \$1.75 on P_2. The problem confronting the manufacturer is how much of P_1 and of P_2 he should make in order to maximize his profits. Also, by what process should he make these products? Finally, he would like to know how much it would cost him (in unearned profits) if he operated his plant at less than the optimum process in order to retain certain intangible benefits from diversified production.

This problem is put into linear-programming form in the following manner: Let X_1 be the amount in thousands of items put through process 1, etc. Then the profit per thousand items is given by the following equation:

$$Z = 1.00\ (X_1+X_2+X_3+X_4+X_5+X_6) + 1.75\ (X_7+X_8+X_9+X_{10}+X_{11}+X_{12}) \qquad [25]$$

Each screw machine is limited in its output so that no more than 40 hr of production may be scheduled per week. For example, the following inequality expresses the limitation on screw machine s_1:

$$40 \geq 2X_1+2X_4+3X_7+3X_{10} \qquad [26]$$

Similarly for the other machines the following *inequalities* result:

$$40 \geq 5X_2+5X_5+7.5X_8+7.5X_{11} \qquad [27]$$

$$40 \geq 4X_3+4X_6+6X_9+6X_{12} \qquad [28]$$

$$40 \geq 1/2X_1+1/10X_2+1/5X_3+X_7+1/5X_8+2/5X_9 \qquad [29]$$

$$40 \geq 2/5X_4+1/10X_5+0.15X_6+4/5X_{10} + 1/5X_{11}+3/10X_{12} \qquad [30]$$

In order to eliminate fractions, multiply the equations through by appropriate constants. To convert the *inequalities* to *equations* introduce the "slack" variables which de-

TABLEAU NO. 1

Variable in Basis	Value	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	E_1	E_2	E_3	E_4	E_5
E_1	40	2			2			3			3			1				
E_2	80		10			10			15			15			1			
E_3	40			4			4			6			6			1		
E_4	400	5	1	2				10	2	4							1	
E_5	800				8	2	6				16	4	6					1
	Z = 0	1	1	1	1	1	1	1.75	1.75	1.75	1.75	1.75	1.75					

in

TABLEAU NO. 2

Variable in Basis	Value	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	E_1	E_2	E_3	E_4	E_5
X_7	40/3	2/3			2/3			1			1			1/3				
X_8	80/15		2/3			2/3			1			1			1/5			
X_9	40/6			2/3			2/3			1			1			1/6		
E_4	229.3	-5/3	-1/3	-2/3	$-\frac{20}{3}$	-4/3	-8/3				-10	-2	-4	$-\frac{10}{3}$	$-\frac{2}{15}$	-2/3	1	
E_5	800				8	2	3				16	4	6					1
Z = -44.3		-1/6	-1/6	-1/6	-1/6	-1/6	-1/6				0	0	0	$-\frac{7}{12}$	$-\frac{7}{60}$	$-\frac{7}{24}$		

The optimum solution is: X_7 = 40/3, X_8 = 80/15, X_9 = 40/6.

E_4 = 229.3, i.e., 22.93 free hours on g_1.

E_5 = -800, i.e., 40 free hours on g_2.

note the amount of unused time remaining on the machines. (E_1 equals excess time available on S_1, E_2 equals excess time available on S_2, etc.)

$$40 = 2X_1 + 2X_4 + 3X_7 + 3X_{10} + E_1 \qquad [31]$$

$$80 = 10X_2 + 10X_5 + 15X_8 + 15X_{11} + E_2 \qquad [32]$$

$$40 = 4X_3 + 4X_6 + 6X_9 + 6X_{12} + E_3 \qquad [33]$$

$$400 = 5X_1 + X_2 + 2X_3 + 10X_7 + 2X_8 + 4X_9 + E_4 \qquad [34]$$

$$800 = 8X_4 + 2X_5 + 3X_6 + 16X_{10} + 4X_{11} + 6X_{12} + E_5 \qquad [35]$$

$$Z = X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + 1.75X_7 + 1.75X_8 + 1.75X_9 + 1.75X_{10} + 1.75X_{11} + 1.75X_{12} \qquad [36]$$

Note that the above equations have the characteristic form for a linear-programming problem, that is, all the equations are linear, there is a linear sum to be maximized *(Z)*, and none of the variables can be negative.

Tableau No. 1 is prepared in the same fashion as the last tableau of the ice cream problem (Table 3). The initial "basic feasible" solution is taken with all X not in the basis set equal to zero. Tableau No. 1 shows the factory idle; the profits are zero and each machine is free 40 hr per week. The profit equation shows that it pays to introduce any X. The first most profitable one, *i.e.,* X_7 is chosen.

Tableau No. 2 indicates that the introduction of processes 10, 11, and 12 would not change the profits. If for reasons of prestige or consumer relations P_1 must be produced, Tableau No. 2 shows, for this case, each process is equally expensive.

AUTHORS' NOTE: When this paper was prepared for presentation at the ASAE winter meeting in Chicago, neither of the authors had sufficient familiarity with agricultural problems to hazard including one in the paper to be given at that time. Since then, however, a number of typical problems amenable to linear programming have been brought to the authors' attention. Some of these are: *(a)* purchase of fertilizers at minimum cost, *(b)* choice of crops to plant in face of limited water, soil fertility, government restrictions and variable cost of production at various locations, and *(c)* allocation of feed among types of livestock. Further examples may be found from time to time in "Econometrica".

Discussion

William H. Yaw

Affiliate ASAE

WHEN I read the foregoing paper, I realized that the work closely resembles the statistical control work which I learned to do for the USAF at Harvard University about ten years ago.

It is interesting to note that only toward the close of World War II did the complexity of problems force us into this type of analysis. While the terms may confuse one at first, in the case of engineers with mathematical backgrounds, the techniques may be acquired quickly. I was much relieved to read in Dr. E. O. Heady's bulletin (see appended references) that a junior clerk can acquire the skills necessary to do this work, but I would add "a junior clerk with a very flexible set of brains or a graduate student." It takes a good deal of bandying about this technique before one acquires the skills to use it, particularly without matrix or vector algebra experience.

The simplest way to define linear analysis, in my opinion, is that it is "a jet version of budgeting." This is true whether the simplex method is used or matrix or vector algebra techniques. George Dantzig of the Rand Corp., Santa Monica, Calif., is generally credited with working out the simplified simplex techniques for the USAF. Incidentally, the Berlin Airlift was linear programmed.

Budgeting and linear analysis are the same general technique. Both use the assumptions of linearity and constant input-output ratios. Both have the same limitations. "If one gives you a screwy answer," to quote Dr. Heady, "so will the other."

There are some differences between budgeting and linear analysis. Budgeting is seldom used to find the one unique production program out of many which may be the maximum or the optimum answer. Linear analysis has advantages for large-scale problems. You can specify the optimum in a fraction of the time required for cumbersome budgeting. Thus we develop this general rule: when the problem is large scale, use linear analysis; when it is small scale, use budgeting.

Linear analysis also can dig deeper into problems. An illustration of this might be the classic example in agriculture of breaking down the yearly labor supply into monthly labor aggregates. For instance, our livestock labor on cornbelt farms is known to vary from 250 hr roughly to 500 hr per month at peak-labor loads. By budgeting, it is seldom feasible to break down labor into subclasses by months or weeks, or soil into different classes, etc., until there are perhaps 50 different resource groups to limit production at specified optimum combination enterprises.

Linear analysis is used where two or more fixed resources serve in a limitational capacity to the final program. Under the assumptions of the method you must have *(a)* constant coefficients and *(b)* resources in fixed proportions. Generally speaking, there is no reason to set up matrices and work out lengthy solutions if all resources are variable. Usually linear analysis should be used only where there is an "opportunity cost" or parallel problem. There is a technique where this general rule is an exception, but I will not go into it here.

Following are six basic steps of linear analysis which should be helpful in orienting oneself and starting to utilize the technique:

1 Assembling input-output coefficients and prices or parallels in other fields of endeavor. This is where judgment and accuracy enter the picture and where failure to use it properly can give the screwy answers mentioned above. To put it another way, one must first specify the supplies of fixed resources which can limit the program.

2 Determine the input requirements or coefficients. The figuring and thinking which go into the coefficients are the *important considerations* of linear analysis.

3 "Lift" the matrix out of your table determining the input coefficients. This simply lists the input coefficients alongside prospective resources and their supplies. The figures in your first matrix table suggest how resources might be used. Here we have to recognize that a resource need not be used, and in doing so we introduce the mechanics for this technique by the term "disposal enterprise". An example of this might be the farmer leaving hay lie idle in the barn for a few years, or silage in an open pit silo, if

The author—WILLIAM H. YAW—is co-owner, The Farm Clinic, West Lafayette, Ind.

the market does not justify buying livestock to feed out the item. An example in industry where a chain of manufacturing techniques are set up to mass produce something is that a machine might occasionally be left idle and the men go out for a coffee break, rather than keeping all machines tooled up and all men at maximum work per day. We need a disposal enterprise or non-use enterprises for each of the resources considered in planning.

4 Next the table must be expanded to include the disposal enterprises the same as for usable enterprises, also including "input" coefficients for these "non-use enterprises". In terms of mathematics, we have now set up a matrix with N rows representing possible limitational resources; and $K+N$ columns where K equals the real activities and N equals the disposal enterprises.

5 Then we transfer our expanded table into a larger table which now gives us room for vertical expansion, adding an opportunity cost and marginal revenue row beneath each set of resources and an R column at the right for the purpose of determining our limitational resources.

6 From here on it is a question of mechanics which you study until you can master the technique.

I see one weakness in the program. After careful thinking and working through the coefficients and setting up the plan, we can get it halfway through the machine and have the machine break down and our farming enterprise go broke before we get it to working successfully again. I am sure you realize this is a bit far-fetched, but it does serve to bring to mind the fact that we are sometimes "slaves to our gadgets" in this complicated age.

Applying Linear Analysis to Farm Structures

The amazing thing about statistical work in the USAF was the way in which distances, transportation difficulties, bomb loads, crew requirements, weather hazards, enemy-inflicted losses, food intake, etc., were lumped together and organized into logical answers. This no doubt grew out of the coordinated reports from specialists in various fields of endeavor and the necessity of resolving all differences into a final objective.

If your plants run true to many other industrial concerns, there is the problem that the specialists in each field are in touch only with their own immediate problems and may be dominated by a president whose specialty influences his primary thinking. Or it may even be that the administration staff has limited technical knowledge. It is entirely possible that the most vocal of the engineering heads get their plans incorporated when new chunks of money are available.

I hesitate to make broad statements about manufacturing of farm structures because I feel all of you are in the midst of the field and I am just an observer. However, in the technique of linear analysis there is virtually no limit to the possibilities which can simultaneously be compared; whether the problem is one of stress, costs, durability, or other. In designing structures of the future, perhaps temperature, moisture, humidity, space requirements (flexibility thereof), use value, and other points are getting more emphasis than in the past when being considered with the engineering inputs. If you can find ways to study this technique and get a picture of where you are going to go without working it through, linear analysis gives many unbiased answers that can assist. Linear analysis can be helpful. It will give you opportunities for short cuts that budgeting alone will not permit. This is in addition to the advantages offered by the technique for more complicated problems.

Limitations of Linear Analysis

Just a word about linear analysis limitations. Without pretty careful judgment, one can very easily get into the position of considerable mathematical gymnastics that are unnecessary and thus bog down with a problem.

Poor judgment in assembling the input-output coefficients will give severe distortion in one's answer. It may become valueless.

Linear analysis is complex.

Determining whether to budget or solve the problem by other methods of linear analysis.

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Preventing Crop Losses By Drying

(Continued from page 415)

cost of removing the water using heated and unheated forced air with the value of product from which the water is removed, a method is provided for determining the economical value of the two systems. The unheated-air system is economical for the removal of 13,000 lb of water or more per year, and the heated-air system is economical for removal of 113,000 lb or more per year based on the prevention of losses (Fig. 1). The removal of 13,000 lb of water would be from 1,730 bu of corn, or 3,420 bu of wheat, or 19.5 tons of hay. The removal of 113,000 lb of water would be from 15,060 bu of corn, or 29,730 bu of wheat, or 169 tons of hay. Other advantages may contribute to the value of drying and make it economical at lower crop volumes. This paper was written to show the advantages of crop drying from consideration of *losses* only.

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NEWS SECTION

V-Belt Seminars for Industry Engineers

A SERIES of nearly 30 V-belt seminars for major manufacturers of farm equipment throughout the nation are being conducted this year by the Agricultural Division of Dayton Rubber Co. The first seminar was held March 6 at the New Holland Machine Co., New Holland, Pa. Main portion of each program is a slide lecture covering problems encountered in the development and production of specialized V-belts for the farm equipment industry. The slides are followed by a blackboard demonstration of various V-belt drives and their application. The meeting closes with a question-and-answer period.

A raw material display accompanying the program shows the basic rubbers, chemicals and fibers used in V-belt production. How each of these materials performs a definite function within the belt structure, and how the slightest variation in their percentage or position in the belt mix affects the finished product's performance are explained. With the aid of slides, it is also pointed out how the research and development engineer must select, from a large variety of raw materials, those which will perform in such a manner as to meet a specific V-belt need by experimenting with and eliminating any number of components until the right combination results.

An explanation of the company's testing procedure begins with laboratory tests for determining V-belt tensile strength, tendency to fray, noise-generating characteristics, conductivity and static-generating properties, performance at extreme high and low temperatures, slip and stretch characteristics, flexibility, performance and life expectancy with and without loads.

When an experimental model passes all the rigorous laboratory tests, it is field-tested to check on other factors, such as weather, faulty maintenance and foreign materials picked up while the belt is in operation under actual working conditions.

ASAE Meetings Calendar

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

August 28-30—NORTH ATLANTIC SECTION, Riley-Robb Hall, Cornell University, Ithaca, N. Y.

October 24-26 – PACIFIC NORTHWEST SECTION, Penticton, British Columbia

December 9 to 12 – WINTER MEETING, Edgewater Beach Hotel, Chicago

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

True D. Morse on ASAE Program

THE Honorable True D. Morse, Under Secretary of Agriculture, will be principal speaker at a joint session of the National Joint Committee on Grassland Farming and the Power and Machinery Division of ASAE, Wednesday, June 20, at Hotel Roanoke, Roanoke, Va., during the 49th Annual ASAE meeting.

TRUE D. MORSE
Under Secretary of Agriculture

As Under Secretary of Agriculture, Mr. Morse is second in authority to the Secretary. Also, as president of the Commodity Credit Corporation, he heads the multibillion dollar corporation responsible for the direct price support programs and related activities of the Department.

Mr. Morse is a member of the President's Advisory Board of Economic Growth and Stability. He headed the United States delegation in negotiating the renewal of the International Wheat Agreement; also in negotiating the International Sugar Agreement in London (1953).

Prior to coming to Washington in January, 1953, he had been in the farm management and agricultural service business for 26 years, and his work had taken him into all parts of the United States and into Canada. Mr. Morse was president of the Doane Agricultural Service, Inc., and before resigning from that organization to take his present post had been elected chairman of the board. He was editor of the *Doane Agricultural Digest* from its origin in 1938 until 1953.

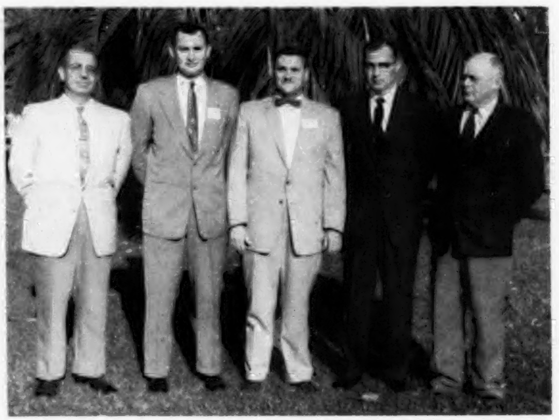
Virgil Overholt Elected Fellow of ASAE

THE Council of ASAE recently elected Virgil Overholt to the grade of Fellow in the Society.

Virgil Overholt was born in 1889 and graduated with a BS degree in agricultural engineering from Ohio State University in 1915. He began his work in water management as an extension specialist at Ohio State in July of that year. After two years, he entered the U.S. Army as a private in artillery and served 20 months of which thirteen were overseas. He was discharged as a first lieutenant. After discharge, he resumed his work at Ohio State University as

(Continued on page 440)

Representatives of the Agricultural Division of the Dayton Rubber Co., who will conduct V-belt seminars for farm equipment industry engineers throughout the country during the year. *(Left to right)* W. O. Terrill, sales engineer; E. K. Lofton, sales manager; R. S. Gove, district manager; and W. E. Wayland, field sales manager



Newly-elected officers of the Florida Section of ASAE: *(left to right)* Clarence J. Rogers, University of Florida, treasurer; J. Mostella Myers, Florida Agricultural Experiment Station, secretary; Walter J. Eichelberger, Food Machinery and Chemical Corp., chairman; Herman W. Glover, Douglas Fir Plywood Assn., vice-chairman; and John W. Randolph, Everglades Experiment Station, vice-chairman

With the ASAE Sections

Pennsylvania Section

Arthur W. Clyde, who will retire soon, after 25 years service in the department of agricultural engineering at Pennsylvania State University, was honored in a surprise tribute during the banquet program of the Pennsylvania Section meeting held at the Eutaw House, April 12. A bronze plaque, mounted on walnut, honoring Mr. Clyde's contributions to the development of agricultural engineering, was presented by H. H. Nuernberger, chairman, in behalf of the Pennsylvania Section. A set of tools for working with both metals and wood was a gift from the agricultural engineering alumni at Pennsylvania State University.

A framed portrait of Mr. Clyde was presented by the Pennsylvania Student Branch of ASAE and is to be added to the portraits hanging in the agricultural engineering building. John E. Nicholas, a colleague of Mr. Clyde's for most of his teaching career, presented a bound volume of more than 100 testimonial letters from friends and associates.

Many interesting papers were presented during the two-day Section meeting on the Pennsylvania State University campus. On Thursday afternoon, April 12, an activity report on Pennsylvania farm electrification council was presented by Roy Smith. It was followed by a progress report on handling and processing grain on the farm, by Ralph P. Prince. A panel on trends in merchandising specialty farm equipment was presented by L. S. Singley, West Penn Power Co.; D. C. Sprague, GLF Farm Supplies; and J. B. Stere, New Holland Machine Co. Following the panel discussion, William C. Wenner, Jr., Northwestern Rural Electric Co-op, spoke on a farm wiring improvement program. A paper on principles of flood prevention design was presented by Joseph Bornstein, U.S. Soil Conservation Service, and F. W. Peikert, head, department of agricultural engineering, Pennsylvania State University, concluded the Thursday program with a paper on design of irrigation systems.

On Friday morning, April 13, John Walker, extension agricultural engineer, spoke on design of pole structures. A. E. Cooper, extension agronomist, spoke on forage crops and football. A business meeting followed.

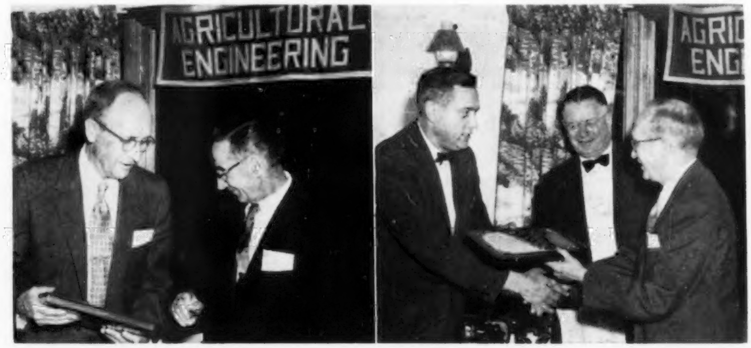
Florida Section

Walter J. Eichelberger, sales engineer, Food Machinery and Chemical Corp., was elected chairman of the Florida Section during a meeting, April 20 and 21, at the University of Florida student service center, Gainesville. Other new officers included Herman W. Glover, Douglas Fir Plywood Association, John W. Randolph, Everglades Experiment Station, and Louis C. Brenner, International Harvester Co., Jacksonville, as vice-chairman; C. J. Rogers, University of Florida, treasurer, and J. M. Myers, Florida Agricultural Experiment Station, secretary.

Nearly 50 members were in attendance for the two-day affair. The Friday afternoon program included papers on aluminum for agricultural use by W. S. Ellis and W. L. Willis, Aluminum Company of America; types, grades and uses of plywood, by Herman W. Glover, Douglas Fir Plywood Association; the role of the electric co-op in farm electrification by E. N. Butler, Suwanee Valley Electric Co-op; progress report of the Florida Water Resources Study Commission, by David B. Smith, director; and irrigation for pasture by J. Mostella Myers, Florida Agricultural Experiment Station. Business meeting and election of officers followed.

Guest speaker at the annual section dinner, held Friday evening, was Albert Wass de Czege, agricultural engineer and author, who spoke on the agricultural engineer in Europe.

During the Saturday morning program, Frazier Rogers, head, department of agricultural engineering, University of Florida, spoke on agricultural engineering at the University of Florida. J. A. Luscombe of the Southeast Cotton Ginning Laboratory, spoke on cotton ginning research in the Southeast. Automation in agriculture in the Florida Everglades was described by John W. Randolph of the Everglades Experiment Station. The final paper on the program was on potato harvesting and handling machinery, by John S. Norton, assistant agricultural engineer, University of Florida.



Arthur W. Clyde was honored in a surprise testimonial at a recent ASAE Pennsylvania Section dinner. *(Left)* Mr. Clyde, at left, receives a bound volume of more than 100 testimonial letters written by friends and associates. The presentation was made by John E. Nicholas, long-time colleague. *(Right)* H. H. Nuernberger, chairman, Pennsylvania Section, presents Mr. Clyde with a bronze plaque mounted on walnut, honoring his contributions to the development of agricultural engineering, as a gift from the Section. B. P. Hess, in center, served as toastmaster

Michigan Section

Robert J. Alpers, sales engineer, Michigan Vitrified Tile Co., and president of the Michigan Vitrified Drain Tile Manufacturers Assoc., was elected chairman of the ASAE Michigan Section at a meeting held April 20, at Dearborn Inn, Dearborn. Tom Wilkinson, Ethyl Corp., M. L. Esmay, Michigan State University, and Ralph C. Frevik, Tractor & Implement Div., Ford Motor Co., were elected vice-chairmen.

At ASAE Michigan Section meeting held at Dearborn Inn, Dearborn, April 20. *(Left to right)* A. W. Farrall, head, agricultural engineering, Michigan State University; ASAE President Wayne H. Worthington; Robert L. Erwin, outgoing Section chairman; Irving A. Duffy, vice-president of Ford Motor Co. and general manager of Tractor and Implement Division; and Robert J. Alpers, sales engineer, Michigan Vitrified Tile Co., newly-elected Section chairman

Newly-elected officers of the Michigan Section of ASAE: *(Left to right)* Clarence M. Hansen, Michigan State University, secretary; Thomas J. Wilkinson, Ethyl Corp., vice-chairman; Merle L. Esmay, Michigan State University, vice-chairman; Ralph C. Frevik, Tractor and Implement Division, Ford Motor Co., vice-chairman; and Robert J. Alpers, Michigan Vitrified Tile Co., chairman. The Michigan Section will serve as hosts for the Golden Anniversary meeting of ASAE in June, 1957

Clarence M. Hansen, Michigan State University, was elected secretary.

During the afternoon program, Harold E. Pinches, assistant director of farm and land management, U. S. Department of Agriculture, discussed the subject of management engineering in agricultural practices. J. M. Apple, mechanical engineering department, Michigan State University, discussed time and motion analysis in product planning for industry and how it might relate to the farm. H. J. Barre, consulting engineer, discussed the relationship between buildings and material-handling equipment.

Wayne H. Worthington, president of ASAE, spoke on the importance of agricultural engineering, and pointed out that agricultural engineers, through the Society, provide a meeting place to collect, discern and dissimulate the problems of engineering information in agriculture. He indicated also that a big educational program is necessary in order to further the establishment of the engineering profession in the minds of many.

Irving A. Duffy, vice-president of the Ford Motor Co., and general manager of Tractor and Implement Division, was the speaker at the evening banquet. He discussed the future role of the American farmer from the present period of surpluses to the time when increased population will demand top production from crop land. He mentioned that farm machinery developed for better working conditions and fewer hours, new structural materials, increased operator comfort, combining operations, agricultural chemicals, mechanical handling and push-button operation are illustrations of how agriculture can be improved to meet possible food shortages in the future.

Alabama Section

Lawrence Ennis, extension specialist in soil engineering, API, was elected chairman of the Alabama Section at a meeting held in Dothan, Ala., on April 20 and 21. J. F. Hixon, Alabama Power Co., was elected vice-chairman and William T. Cox, Alabama Extension Service, was elected secretary.

Tours of the Dothan Oil Mill, Sunnyland Packing Co., and W. F. Covington Planter Works, highlighted the Friday afternoon program. At the Dothan Oil Mill, the group observed the process of extracting oil from peanuts and cottonseed and refining it for home use. At the Sunnyland Packing Co., the group had an opportunity to see how livestock is handled from the time it arrives at the packing plant until it is ready for the table. The complete manufacturing process of a tractor-mounted planter from the raw material to the completed product was traced in a conducted tour of the W. F. Covington Planter Works.

Speaker for the Friday night banquet was Lyle Brown, extension specialist in visual aids, API, who gave an informative and interesting talk on the use of photography as a teaching aid. The Alabama Section also presented Hurst Mauldin with a gift in token of appreciation for his efforts as editor of the *Alabama Agricultural Engineer.*

The Saturday morning program opened with a talk by W. F. Covington, in which he gave a brief resume of the development of the Covington planter. Oscar Floyd, Russell-Daniel Irrigation Co., showed a film on the history and development of irrigation, and Douglas Johnston, John Blue Co., presented a paper on the problems of metering anhydrous ammonia.

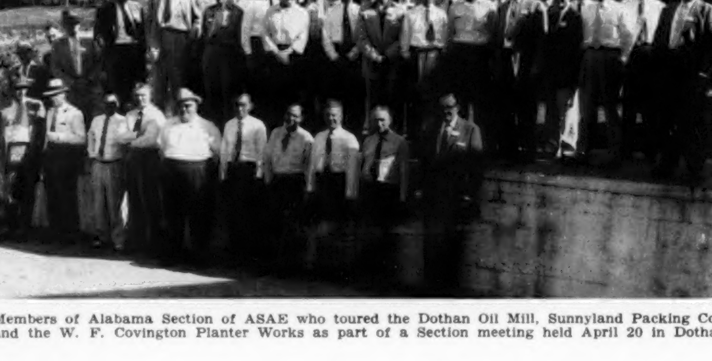
Minnesota Section

Arthur E. Kvamme, superintendent of building sales, Armco Drainage and Metal Products, was elected chairman of the Minnesota Section at a meeting, April 26 in the agricultural engineering building on the farm campus, University of Minnesota, St. Paul. Curtis L. Larson, University of Minnesota, was elected vice-chairman. Vernon M. Meyer, University of Minnesota, is the new secretary-treasurer. Eugene C. Meyer, Minneapolis-Honeywell Regulator Co., and Fred W. Kesler, Rilco Laminated Products, Inc., were selected as director and alternate director, respectively, to the Minnesota Federation of Engineering Societies. A. M. Larson, Uhl Co., was elected as contributing editor. The new nominating committee consists of K. W. Westerberg, E. R. Allred, and Burt E. Ryberg.

ASAE President Wayne H. Worthington was speaker at the annual dinner preceding the business meeting. In the afternoon a tour of selected research projects in agricultural engineering was conducted. To conclude the afternoon program, a colored sound movie, entitled "Land of Plenty," was shown. The film was produced on the Michigan State University Centennial in 1955 showing the progress of agriculture during the past 100 years and the role of agricultural engineering in this development.

Oklahoma Section

A spring meeting of the Oklahoma Section was held at the U.S. Naval Ammunition Depot, McAlester, Okla., April 27.



Members of Alabama Section of ASAE who toured the Dothan Oil Mill, Sunnyland Packing Co., and the W. F. Covington Planter Works as part of a Section meeting held April 20 in Dothan

Fred R. Gray, Section chairman, from the U.S. Soil Conservation Service at Ada, presided at the morning session. To begin the program the group was welcomed to the depot by Captain John W. Murphy, commanding officer. Ed D. Rhoades, depot soil conservationist, pointed out some of the special problems in controlling erosion in the vicinity of ammunition storage structures. One of the special requirements for the erosion control program on the depot is to maintain a vegetated cover on the earth-covered concrete magazines.

A field trip in the afternoon provided an opportunity for the group to observe results of erosion control methods and to see special demonstrations of machinery and equipment being used for grading, sodding, fertilization, and watering. One of the interesting features of the afternoon program was a trip through one of the ammunition buildings to observe workmen in production line operation of 40-mm shells.

Ohio Section

Truman Goins, assistant professor of agricultural engineering, Ohio State University, was elected chairman of the Ohio Section in a recent election of officers conducted by letter ballot. Robert C. Evans, International Harvester Co., was elected as vice-chairman, and Edwin Smith, Dayton Power and Light Co., was elected secretary-treasurer.

North Atlantic Section

A meeting of the North Atlantic Section will be held August 28, 29, and 30, at the new agricultural engineering building (Riley-Robb Hall), Cornell University, Ithaca, N. Y.

The first half day will be devoted to topics of general interest to the entire membership. Freedom's need for the trained engineer will be discussed by Dean S. C. Hollister of the Engineering College at Cornell.

A joint farm structures and rural electric session is scheduled for August 28 for the presentation of such topics as animal shelter ventilation, farm apple storages, and recent research in potato storage ventilation and and handling equipment.

Four concurrent technical programs are planned for the morning of August 29. Farm power and machinery topics are fuels and lubricants for farm machinery, potato harvester development in Maine, new trends in tractor tire design, fundamentals of radio active isotopes, radio active tracers in fertilizer placement, bearing applications for farm machines, and analysis of silage movements through a blower. The farm structures program includes the application of asphalt roofing products to low sloped roofs, an all plywood poultry house, the economic aspects of aluminum roofing sheets, and a report on poultry housing in the Northeast from the Northeast Technical Committee. The soil and water session will include such topics as rainfall intensities, irrigation requirements for New England as determined by rainfall and drought probability studies, hydrology as it applies to flood control, soil compaction, sub-soiling or deep tillage, consumptive uses of water, and statistical methods in hydrologic studies for flood prevention.

The rural electric group have scheduled speakers on the subjects of a heated septic tank for disposal of dead chickens, experiences in crop drying, soil heating with electric cable, and betterment of farm wiring.

(Continued on page 436)

L. A. Murphy, member of ASAE since 1936, was elected senior vice-president of Deere and Co. at a recent meeting of the board of directors. Mr. Murphy has been with Deere and Co. almost 34 years. He has been a director of the company since 1937 and a vice-president since 1943. In his new appointment he will devote much time to long-range forward planning.

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Walter M. Carleton, professor of agricultural engineering, Michigan State University, has been appointed as assistant chief of the Agricultural Engineering Research Branch (ARS), U.S. Department of Agriculture, and will report for duty on July 9 at the USDA Plant Industry Station at Beltsville, Md. He will assist E. G. McKibben, chief of AERB, in planning, directing and coordinating research projects in agricultural engineering, including farm machinery, farm buildings, mechanical processing of raw farm products, and farm electrification.

In accepting his new post, Dr. Carleton resigns from the agricultural engineering staff of the Michigan State University, with which he was associated for more than six years, as professor, as graduate student advisor, and as advisor for agricultural engineering research programs.

Born in Coldwater, Kansas, he obtained a B.S. degree in agricultural engineering at Kansas State College in 1938, and an M.S. degree at Iowa State College in 1946. He obtained his doctorate in agricultural engineering at Michigan State University in 1948. He also served as a rural service engineer for the Kansas Power and Light Company from 1938 to 1940, extension engineer at Kansas State College from 1940 to 1941, and instructor in agricultural engineering at that institution from 1941 to 1943. From 1943 to 1945, he served as officer in the United States Navy having duty assignments in the United States and the Pacific area.

Dr. Carleton is author and co-author of more than 20 publications covering widely varied fields in agricultural engineering and of a textbook on farm tractors, a work now in use in more than 30 colleges of the United States.

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William V. Hukill, farm buildings section, agricultural engineering research branch (ARS), U. S. Department of Agriculture, was recently awarded the National Civil Service League 1955 Merit Citation "in recognition of an outstanding career in the public service." The league grants awards to ten career employees each year who exemplify their careers by ". . . competence and efficiency, character, and continuity of service."

Mr. Hukill has been on the agricultural engineering staff of the USDA for 32 years. Since 1943 he has been stationed at Iowa State College, Ames, where he is currently engaged in cooperative federal-state research studies concerning grain storage and conditioning.

Mr. Hukill is a nationally recognized authority on refrigeration for the transportation of fresh fruits and vegetables by rail, on engineering phases of apple storage problems, as well as on storage of ear and shelled corn, wheat, grain sorghum, and soybeans. He was responsible for finding the cause and cure for moisture concentrations that occur in masses of stored grain during weather changes and which frequently result in deterioration of stored grain or seed. He also played a leading role in stimulating research to find efficient and economical methods of storing combine-harvested grain.

ASAE MEMBERS in the News

L. A. MURPHY

W. M. CARLETON

W. V. HUKILL

W. H. KNIGHT

William H. Knight, director of the Idaho farm electrification project, has been appointed as head of the office of technical extension services in Washington State College's Institute of Technology. He will also carry the title of associate engineer. Mr. Knight holds degrees in agricultural engineering from Washington State College and the University of Idaho. Following a year with the Washington Water Power Co., he joined the University of Idaho staff in 1947. He served as associate professor and associate agricultural engineer at the University of Idaho. He is a member of the National Farm Electrification Conference Research Committee and the Idaho Intra-Industry Farm Electric Utilization Council.

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E. R. O'Neill, Jr., has been promoted to the position of manager, tractor product planning dept., and **R. R. Owen** has been named as manager, implement product planning dept., Tractor and Implement Div., Ford Motor Co.

Mr. O'Neill, a native of Schenectady, New York, and a graduate of West Virginia University, has been manager of the implement product planning dept. since October, 1955. He joined the company as a personnel representative in 1947, following five years of service with the U.S. Army Air Force during World War II.

Mr. Owen, a native of Yuma, Arizona, and graduate of the University of California, had been head of the agricultural engineering dept. of the Pineapple Research Institute at Honolulu, Hawaii, for the past six years. Prior to that, he was a technical service representative with E. I. duPont de Nemours and Co.

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Glen D. McLaren has resigned his position as blockman for Allis-Chalmers Mfg. Co., and has taken employment as an agricultural engineer with the U.S. Soil Conservation Service at Erie, Kansas.

Ralph C. Hay has returned to the University of Illinois after establishing and serving as the first head of the agricultural engineering department of the Indian Institute of Technology, West Bengal, India. Shortly after returning from India, he served on a temporary assignment as acting ICA coordinator for the University of Illinois. He is now back at his duties as professor of soil and water in the agricultural engineering department.

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Harrison C. Cornish, formerly farm service representative, the Connecticut Light and Power Co., has resigned to accept a position with the Central Hudson Gas and Electric Corp., Kingston, N. Y.

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Robert P. Harbage has accepted a position with the New Idea Division of Avco Manufacturing Co. Previously he was employed by the Proctor and Gamble Co.

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John H. Hough has taken a position in the technical department of the National Lumber Manufacturers Assoc., and will work out of the Association's New Orleans office. He will deal primarily with building code matters and the technical utilization of lumber. Previously he was assistant professor of agricultural engineering in the field of light-frame construction at Louisiana State University. Also for a period of two years, he served as field engineer for the Southern Pine Assoc. in New Orleans, developing manuals and technical information, working with contractors and architects, and teaching short courses in timber construction at several universities.

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Keith H. Hinchcliff has returned to the University of Illinois after serving for about two years as housing specialist in Djakarta, Indonesia. He will resume his activities as professor of farm structures in the area of farm housing at the University of Illinois.

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Easley S. Smith has resigned his position as territory manager for The Oliver Corp., to become extension agricultural engineer at Virginia Polytechnic Institute to handle the farm machinery phase of the Virginia Extension program which includes work in the 4-H tractor program.

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Paul E. Fischback, district extension irrigation engineer at Minden, Nebr., is now located at the University of Nebraska in Lincoln as an assistant extension agricultural engineer.

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Harry B. Pfost, former division engineer, Green Giant Co., has accepted a position in the product planning and programming office, Tractor and Implement Div., Ford Motor Co.

NECROLOGY

Herbert H. Gee died from a heart ailment on March 24 while visiting his mother at South Hill, Va. He was born December 6, 1925, and received a B.S. degree in agricultural engineering from Virginia Polytechnic Institute in 1950. He joined the VPI Agricultural Extension Service in 1953 and served as assistant agricultural engineer in charge of the farm building plan service. From September, 1955, to the time of his death he was on educational leave to take graduate work at VPI.

NEW PRODUCTS CATALOGS

Adds Power Steering

Allis-Chalmers Mfg. Co., Milwaukee, Wis., announces that power steering is now available for the Model WD-45 tractor as a factory installation for dual or single front wheel or adjustable front axle types. In addition, power steering is also available as a field installation for Model WD-45 tractors in the hands of owners and also for all Model WD tractors produced since 1948.

The new power steering system is a full-time hydraulic assist—as the steering wheel is turned, power steering goes into effect. The system is a hydraulic gear motor type and is equipped with a centering device which acts to return the steering wheel to neutral position. This is said to reduce tendency of front wheels to drift while driving on the highway.

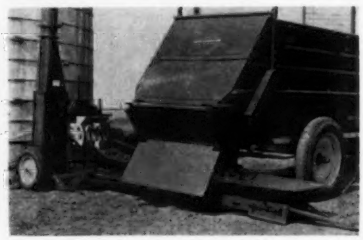
Oil Seal Booklet

Chicago Rawhide Mfg. Co., has released a new illustrated booklet which tells of an extensive advertising and promotion campaign planned by the company to inform owners of cars, trucks and tractors the importance of having their oil seals inspected, and worn seals periodically replaced. In addition to national magazine and network advertising, the company offers a compact and attractive display cabinet that also stores replacement oil seal sets.

The booklet also describes a new front wheel oil seal installation tool. Included with the tool are 12 plastic converters to fit any size automotive oil seal. The converters also serve as gauges for measuring the wear on old seals. Copies may be obtained by writing to Chicago Rawhide Mfg. Co., Replacement Division, Elgin, Ill.

New Model Forage Blower

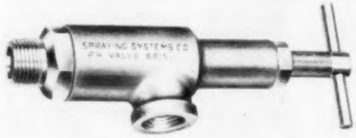
New Holland Machine Co., New Holland, Pa., has introduced a new forage blower, designated as Model 22. The new blower features a long, low feed table, leveler action, high capacity fan blades, and belt feed action. Feed table length and height permit feeding from either side.



Scrapers check material build-up and heavy duck belt cleaners are used to keep silage from getting under the belt. An adjustable star wheel leveler evens the flow of material through a 338-sq in throat. The manufacturer reports that the blower can handle a 3-ton wagon load of silage in as little as 4 min, or a 3-ton load of chopped hay or straw in 5 min.

New Pressure Relief Valve

Spraying Systems Co., 3201 Randolph St., Bellwood, Ill., has announced a new pressure relief valve for use on farm spraying equipment of all types. The new valve was designed to prevent clogging and plugging. Because of the large internal valve area, full flow from supply lines up to ¾-in at normal pressures can be handled. Special inner rib



construction of the valve body is said to permit full flow of liquid around the shut-off piston, thereby preventing the salting out of such chemicals as fertilizer solutions. The piston assembly is mounted within the valve chamber and no gaskets are used as a part of the piston assembly itself.

A double-spring arrangement provides a higher tension control spring at higher pressures and a lower tension spring at lower pressures. The new No. 6815 valves are supplied in brass or aluminum, with stainless steel stem and springs.

New Pull-Type Picker

New Idea Farm Equipment Co., Coldwater, Ohio, has announced its new one-row, pull-type, No. 10 corn picker. Features of the new picker include an ear deflector at the upper end of the wagon elevator with tractor seat control; fewer grease fittings through use of replaceable,

greaseless phenolic fibre bearings; and an easy-to-get-at bank of six lubrication points in a single group of extended fittings for greasing the upper husking roll bearings.

For safety, a lever is provided at the rear of the picker for adjusting the snapping rolls and complete shielding around the PTO shaft extends all the way back to the main drive shaft.

A new spring-loaded lifting mechanism, which raises and lowers the snapping unit, is controlled from the tractor seat. A compression spring allows the snapping unit to rise over ridges in the field and acts as a shock absorber to reduce bouncing when picking in uneven fields. A snap-on universal joint provides easy coupling of picker power line to tractor PTO shaft. Both the PTO hook-up and the triangular hitch reportedly will fit any tractor with ASAE standard PTO and drawbar.

LP-Gas Fuel Controller

Garretson Equipment Co., Mt. Pleasant, Iowa, has introduced a new 2-stage LP-Gas vapor withdrawal fuel controller. The new controller, the Model KV, is designed for use on tractors, stationary engines, and other internal combustion engine applications. The unit can be used with either Butane or Propane, in systems using straight LP-Gas carburetors, adapters or spud-ins. It has the

capacity to handle a wide range of engines, from the smallest internal combustion engine to those up to 180 hp, depending on the orifice used. It also has optional fuel outlets of ¾ and ⅜-in NPT.

The company states that the unit does not require an economizer or intake manifold line. Where it is advisable to use liquid withdrawal, the company also makes a Model K which is engineered to the same specifications as the KV, but it has a water jacket for heating the fuel.

Corn-Combining Attachment

International Harvester Co., Chicago 1, Ill., has introduced a new corn harvesting and shelling attachment for the McCormick No. 141 self-propelled combine.

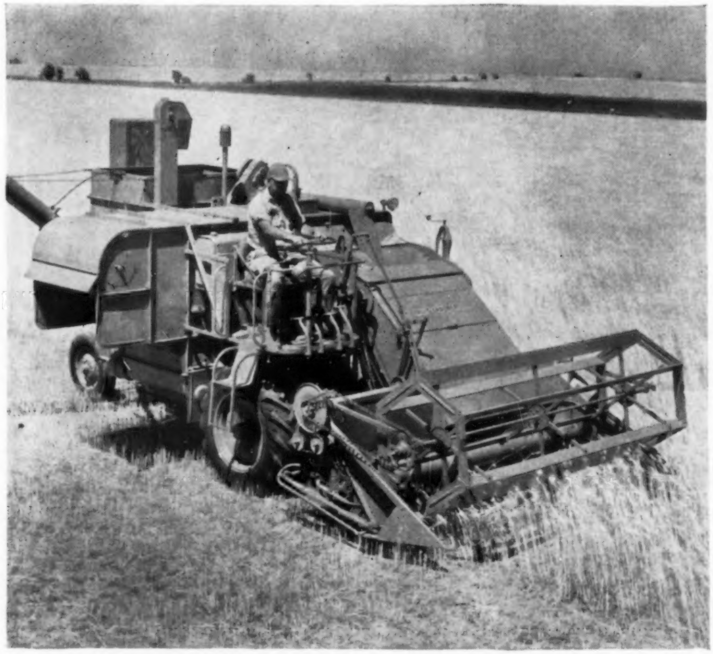
The corn unit, an adaption of the model 2-ME corn gathering and snapping unit, is mounted to the front of the combine after the regular grain platform and certain other parts of the combine have been removed. The attachment is connected to the regular hydraulic lifting mechanism for raising and lowering the gathering unit. Mounting or dismounting the corn unit is said to require about an hour.

In operation, the corn feeds in through the gathering and snapping units and is snapped off the stalk. The ears, husks and all, then are carried up the elevators into the combine between the cylinder bars and the concave. Most of the stalks feed through the snapping rolls and are left on the ground. Shelled corn is elevated to the grain tank or sacker on the harvester-thresher.

The company reports that this new machine can deliver up to 200 bu of shelled corn per hour. Gatherers can be set to run at any desired height up to 35 in above the ground, and the hinged gathering points and center divider can be set to float freely along the ground level.

(Continued on page 430)

How behind-the-scenes services make Link-Belt chain a credit to your machine

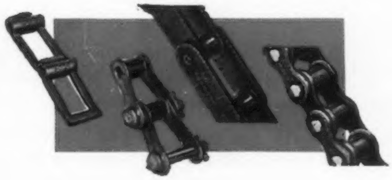


It's Link-Belt double-pitch "AG" roller chain and Steel Link-Belt for the many power transmission and conveying jobs on this Allis-Chalmers Model 100 self-propelled ALL-CROP Harvester. The Link-Belt line includes cast, combination, forged and fabricated chains, roller and silent chain plus matching sprockets and attachments.

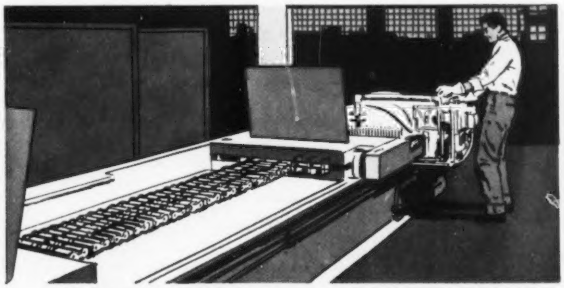
Broad facilities and experience are your assurance of quality chain, correctly applied

THE services illustrated below are part of the exhaustive Link-Belt procedures that guide selection of the right chain for your machine. Link-Belt can make an unbiased recommendation because our line of chains, sprockets and attachments is *complete*. Every pertinent requirement is considered —horsepower, loading, fatigue life, speed, chordal action and many others.

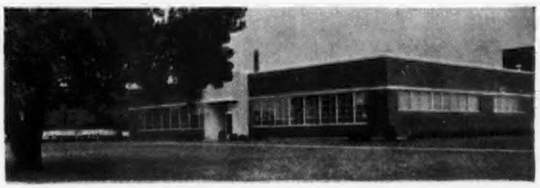
Next time you're faced with a drive or conveyor application, we will be glad to work with your engineers in solving all problems. Contact your nearest Link-Belt office for full information.



EXPERT ENGINEERING AND FIELD TESTING. Link-Belt's engineering staff is unequalled in ability and experience. Working with equipment manufacturers in field tests, they can interpret needs based on chain performance under actual working conditions and make correct recommendations.



ACCURATE MANUFACTURE. Modern, specialized machines allow the economies of large-scale production. Continuous inspections safeguard tolerance and finish of every length of chain. With these extensive facilities, Link-Belt has ample capacity to meet your production schedules.



LABORATORY CONTROL. Every chain bearing the Link-Belt trade ⟩——⟨ mark meets rigid uniformity specifications. Our modern laboratory continuously explores new refinements to increase chain life. It is located adjacent to the world's largest plant devoted to manufacturing drive and conveying chain.

LINK-BELT

THE SYMBOL OF QUALITY

CHAINS AND SPROCKETS

13,983

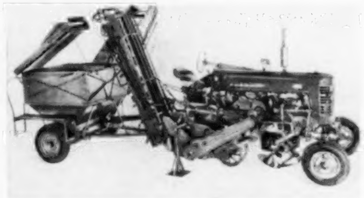
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

New Products and Catalogs

(Continued from page 428)

Sugar Beet Harvester

International Harvester Co., Chicago, Ill., has announced a new tractor-mounted sugar beet harvester, the McCormick 34M-11. The new model can be mounted on the Farmall 300 series of tractors, as well as the Farmall 400, Super MTA, Super M, and the M series of tractors.



Features of the new beet harvester include an adjustment that provides normal clearance for blades or puller wheels, or additional clearance for puller wheels when harvesting on beds. The drop-down hood on the elevator of the new machine has a limit chain for setting the hood in an intermediate position, in addition to the fully raised or lowered position, for directing beets onto the sorting belt as desired.

Materials Handling Catalog

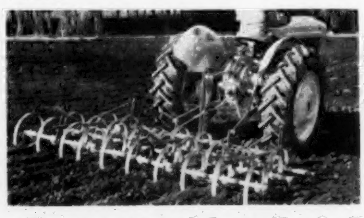
The American Planter Co., Burr Oak, Mich., has published a loose-leaf catalog containing specifications for each model in its complete line of farm elevators, augers, conveyors, silo loaders, bucket elevators, and self-powered hoppers. Also included is a sheet describing wagon boxes, wagon running gears and an automatic feeder system for milking parlors or stanchion feeding, and for hog or chicken feeding.

Included in the line of elevators are the Models 1000Z, all-purpose; 1000, utility; 600, aluminum; 2000, galvanized; 2000 BX, silo-loading kit; 1300, produce elevator conveyor; 600Z, specialty belt conveyor; 3000, bucket elevator; 1500, barn and mow conveyor; 600Z, construction elevator; 2000-C, builder's elevator, and 1000-C, light-duty industrial elevator.

Of particular interest are the various services offered by the company in developing custom units of special manufacture and its practice of contract manufacturing. On the back cover is a handy scale to figure lift and length needs.

Mounted Spring Tooth Harrow

Tractor and Implement Div., Ford Motor Co., Birmingham, Mich., has introduced a new line of 2, 3 and 4-section spring-tooth harrows, designed to mount on all Ford tractors.



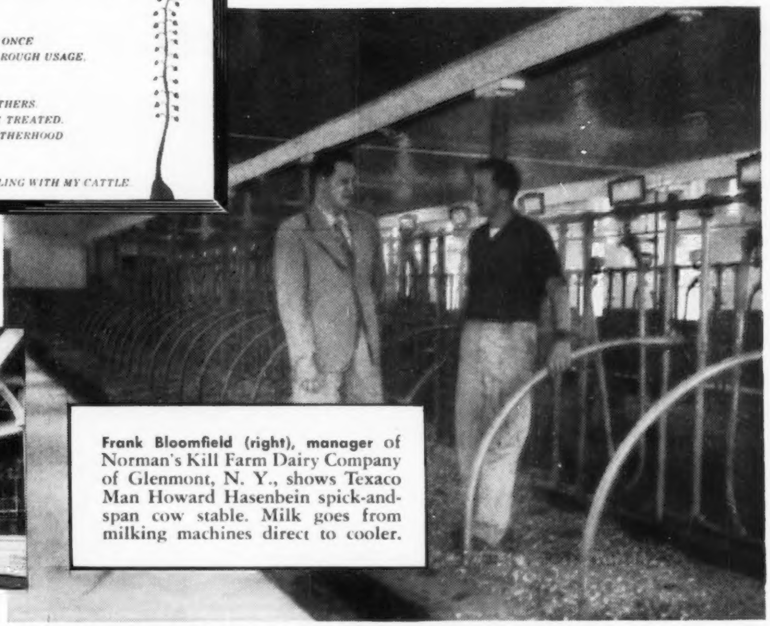
The new spring-tooth harrow line also is available in 2, 3 and 4-section units for use as pull-type implements. Units are available with either pin type or ratchet depth adjustment levers. Each gang unit is approximately 3 ft wide, making spring tooth harrows in widths of 6, 9 and 12 ft.

(Continued on page 432)

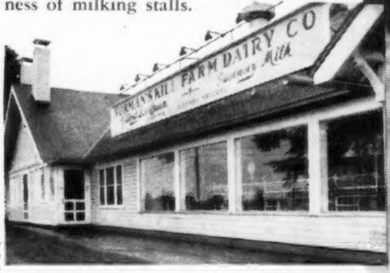
Importance of "STABLE MANNERS" stressed in Milking Parlor

The Rule to be observed in this stable at all times

TOWARD THE CATTLE, YOUNG AND OLD,
IS THAT OF PATIENCE AND KINDNESS.
A MAN'S USEFULNESS IN A HERD CEASES AT ONCE
WHEN HE LOSES HIS TEMPER AND BESTOWS ROUGH USAGE.
MEN MUST BE PATIENT.
CATTLE ARE NOT REASONING BEINGS.
REMEMBER THAT THIS IS THE HOME OF MOTHERS.
TREAT EACH COW AS A MOTHER SHOULD BE TREATED.
THE GIVING OF MILK IS A FUNCTION OF MOTHERHOOD
ROUGH TREATMENT LESSENS THE FLOW
THAT INJURES ME AS WELL AS THE COW
ALWAYS KEEP THESE IDEAS IN MIND IN DEALING WITH MY CATTLE.



Modern milking parlor is located by roadside, has plate glass windows so visitors may watch cows being milked by machines and see extreme cleanliness of milking stalls.



Frank Bloomfield (right), manager of Norman's Kill Farm Dairy Company of Glenmont, N. Y., shows Texaco Man Howard Hasenbein spick-and-span cow stable. Milk goes from milking machines direct to cooler.

THE Norman's Kill Farm Dairy Company of Glenmont, New York, has more than 200 head of registered Guernseys on a farm of 500 acres. Eighty cows can be milked in 2½ hours in the modern milking parlor shown above. Location of the milking parlor by the roadside has proved to be effective advertising for the milk products sold in six states.

Equipment includes forty-five trucks, four tractors, and three auxiliary engines. All are powered by Texaco Fire Chief, the gasoline with superior *"Fire-Power"* for low-cost operation, lubricated with Advanced Custom-Made Havoline Motor Oil and greased with Marfak lubricant.

In Town or on the Highway— In all 48 states—Texaco Dealers will serve you well . . . with top octane Sky Chief gasoline, super-charged with Petrox, to give maximum power and reduce engine wear . . . famous Fire Chief at the *regular* price, both 100 per cent *Climate-Controlled* . . . Advanced Custom-Made Havoline Motor Oil and Marfak lubrication.

"Havoline is the only motor oil ever used in this tractor . . . and the tractor has been going strong now for 18 years," B. E. Jauer *(left)*, prominent farmer, near Robstown, Texas, tells Texaco Consignee Preston Dannelley *(right)*. Havoline wear-proofs engines . . . is the best motor oil money can buy.

Neighborly on-time delivery service—that's the kind farmers and ranchers appreciate and get from Texaco Consignees and Distributors the country over. Texaco Consignee E. A. Hofman of Lynden, Washington, gets an order for Texaco products from Pete Van Zee of Lynden.

TEXACO

ON FARM AND HIGHWAY IT PAYS TO USE

THE TEXAS COMPANY

TEXACO PRODUCTS

DIVISION OFFICES: Atlanta, Ga.; Boston 16, Mass.; Buffalo 9, N. Y.; Butte, Mont.; Chicago 4, Ill.; Dallas 2, Tex.; Denver 3, Colo.; Houston 2, Tex.; Indianapolis 1, Ind.; Los Angeles 15, Calif.; Minneapolis 3, Minn.; New Orleans 16, La.; New York 17, N. Y.; Norfolk 10, Va.; Seattle 1, Wash.

Texaco Petroleum Products are Manufactured and Distributed in Canada by McColl-Frontenac Oil Company Limited.

New Products and Catalogs

(Continued from page 430)

Reversible Scoop

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has developed a two-way tractor-mounted ½ cu yd reversible scoop designed for the model WD-45 tractor. The 31-in wide scoop is made of heavy welded steel plate, fitted with a high-carbon cutting edge.

The scoop is lowered into working position with the tractor's hydraulic control lever. It is balanced on hardened steel pins for dumping when the roller-type latch is released. When empty the scoop automatically returns to the latched position. A shield protects the latch from dirt and mud.

Lumber Booklet

The National Lumber Manufacturers Association has announced publication of a revised and illustrated edition of a 32-page booklet explaining the importance of the lumber industry in the American economy.

The publication traces the growth of lumber manufacturing in the United States from establishment of the first sawmills in the early 1600's to its present-day status as one of the nation's leading industries. Through text and pictures the reader is given a detailed account of sawmill operations and lumber distribution practices.

The booklet also includes a breakdown on lumber consumption and a report on progress made in forest management and log utilization. Single copies of the new edition are available from the Association, at 1319 18th St., N.W., Washington 6, D.C., at no charge. Additional copies are priced at 25 cents each.

Mounted Two-Row Snapper

New Idea Farm Equipment Co., Coldwater, Ohio, has announced a new 2-row mounted corn snapper. The company reports that without moving off his tractor seat, the operator can adjust the snapping rolls to meet weather and stalk variations for minimum plugging and shelling; adjust

the ear deflector at the top of the wagon elevator for even distribution of ears in the wagon; raise and lower the snapping units hydraulically, and operate the clutch to disengage the wagon elevator when turning. An important safety feature is the new mounting ladder. The new No. 321 snapper, which is the company's first mounted, 2-row model, reportedly will fit 18 different tractor models.

(Continued on page 434)

FOR MINNEAPOLIS-MOLINE...

PLOW PARTS BY

PEORIA MALLEABLE

Manufacturing plows equal to the Minneapolis-Moline reputation calls for high standards in parts production. A number of parts on the 2, 3, 4 and 5-bottom Minneapolis-Moline Plows are Peoria Malleable castings – the castings that many leading farm equipment makers choose to produce a quality product.

Often a weldment or a forging can be replaced with a Peoria Malleable casting at a savings in production costs. At the same time, strength and durability is maintained and looks may be improved.

Write for complete facts. For a definite quotation, send specifications. There is no obligation.

A big part of **QUALITY** *is a* **QUALITY** *part*

STANDARD OR PEARLITIC

PEORIA MALLEABLE CASTINGS CO.

FT. OF ALEXANDER ST., PEORIA, ILLINOIS

FAMOUS FOR **QUALITY**

Plowing goes fast with this M-M UB Tractor and 4-bottom M-M Plow.

New Products and Catalogs

(Continued from page 432)

Offset Forage Harvester

Lundell Mfg. Co., Cherokee, Iowa, has designed a new forage harvester with a completely offset hitch. The new machine cuts a 58-in swath with 28 swinging knives which rotate on a central shaft. The tractor runs free of the crop being cut.

The wheels on the rear of the harvester are adjustable to accommodate various grass and row crops. Hydraulic or manual control is optional and the spout is adjustable for delivery height of 9 ft, 8 in rear or 10 ft, 4 in side delivery.

The standard offset hitch is adjustable for hay crops, row crops or transport position. Wheels do not trample the crop being harvested. The caster wheel attachment is available for use alongside trucks. With a motor mount, the chopper can be pulled by the same truck being loaded.

Burlap Booklet

The Burlap Council, 155 E. 44th St., New York 17, N. Y., has published a 16-page booklet, entitled "New Uses for Old Burlap Bags." The booklet, contains many practical ideas for uses of burlap in agriculture as well as elsewhere. Many of these ideas were obtained through a contest recently conducted by the Burlap Council.

New Tractor Series

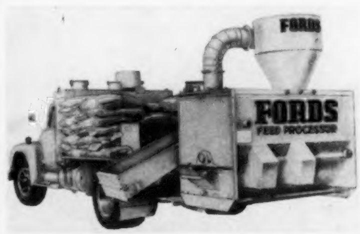
International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced production of the new International 600 series of tractors. The new tractor is equipped with hydraulic power steering, a large platform for the operator, crown-type fenders, complete cowl shielding, roller-type swinging drawbar, improved cold-weather starting for diesel engines, and a new instrument panel.

The tractor is available either in gasoline or diesel models. It replaces the McCormick Super 9 and WR-9S series of wheel tractors.

For operator comfort is a new foam-rubber-padded seat, double cushioned with a coil spring, and hydraulic shock absorbers to ease jars and jolts. This seat tilts back, can be adjusted forward and backward, and can be swung right or left out of the operator's way. The large flat platform has a nonskid floor plate. A one or two-valve hydraulic system to control single, tandem, or multiple hook-ups is available.

Portable Feed Mill

Myers-Sherman Co. of Streator, Ill., has developed a new feed carrier portable processor designed to grind all kinds of feed, mix with supplements, apply molasses and carry its own supply of supplements for on-the-farm feed processing service.



The processing equipment is assembled on a custom-built truck chassis, and has a platform on which a large supply of supplements can be carried. The new unit is equipped with a 24-in hammermill for grinding grain, shelled corn, ear corn and roughages. Mixing is taken care of by a horizontal feed mixer driven by a separate power unit. A molasses impregnator, complete with tank and heater is also part of the equipment.

NEW BULLETINS

Spraying of Crops by Helicopter by W. E. Ripper. Reprinted from the Transactions of the Society of Engineers, Inc. (June, 1955). The 22-page illustrated bulletin presents a thorough report on the factors concerned with the use of the helicopter for applying chemical sprays. The bulletin explains the physics of spraying and contains valuable information on dispersion, dynamic catch, spray drift and special helicopter sprayers. Hydraulic sprayers, spray blowers, mist blowers and fogging spraycopters are covered in separate sections of the bulletin. Also discussed are auxiliary equipment, economics and operation of spraycopters, and utilization. Reprints are available at no charge by writing W. E. Ripper, vice-chairman, Fisons Pest Control, Ltd., Bourn, Cambridge, England.

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Fifth Annual Report of the Nigeria Cotton Marketing Board (Season 1953-54) This report is the fifth and last annual report of the Nigeria Cotton Marketing Board. It reviews the operations of the board from November 1, 1953 to October 31, 1954. It deals with such items as producer price policy, marketing arrangements, selling policy, review of the season's operation, development and research, and the board's accounts and financial position. Copies may be obtained from the Crown Agents for Oversea Governments and Administrations, 4, Millbank, London, or from the Department of Marketing and Exports, Lagos, Nigeria. Price 6d.

Contemporary Farm Houses, Flexiplan 71204, Northcentral Regional Publication 58, Illinois Agricultural Experiment Station Bulletin 600. (Copies available from University of Illinois Press, Urbana, $3.50.) State agricultural experiment stations of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin, and the U. S. Department of Agriculture cooperating. The bulletin was prepared by M. R. Hodgell, under the direction of the Farmhouse Technical Committee (NC-9) of the Northcentral region, and published by the University of Illinois press.

The 11 x 17-in plan book contains the latest information regarding planning and construction of homes, selection of windows, storage space, heating, utilities, and lighting as well as outdoor planning and planting.

The Flexiplan consists of 24 sections or divided sheets which pivot from plastic bindings at the outsides of the plan book and join in the center. Any one of the planned sections on the left side can be put together with any one on the right side to form a complete floor plan. A total of 576 house plan combinations is possible and alternatives in choice of basement, garage, or porch offers more variations.

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Materials Handling (second edition) by the editors of *Successful Farming* published by the Meredith Publishing Company, Des Moines 3, Iowa. The new edition has been enlarged and revised to include new developments since the first printing in 1955. In addition to the sections on grain handling, hay handling, silage handling, water handling, manure handling, and materials you buy, that were included in the first edition, the new edition includes a beef feeding system that fits the cattle, how a farmer can double his herd size, how materials handling principles work for one farmer, and an article on how equipment makes a poultry operation work. Copies may be obtained from the Meredith Publishing Company at 25 cents a copy. Quantity prices are available.

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NIAE Bulletin. The following bulletin has been received recently from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England.

Agricultural and Horticultural Engineering Abstracts—Vol. VI, 1955, No. 4 Abstracts from World Literature.

With the ASAE Sections

(Continued from page 424)

The afternoon and evening of August 29 has been left open for optional recreational activities such as trips to the Corning Glass Works and nearby state parks and visits to local industries. A chicken barbecue is planned for the evening.

An all-day feature program is scheduled for August 30 that should be of interest to all members. The engineer in today's dairy farming will be the theme throughout the day. A few of the topics already listed are management engineering in agriculture with special reference to dairy farming, the dairy farmer and mechanical grazing, hay drying equipment, development of mechanical metering equipment for silage unloading, mechanical feeding in bunkers, new portable milker, hot water requirements on dairy farms, hay crushing, evolution of the dairy enterprise, loose housing vs. stanchion barns, and zero pasture.

The three-day-program will be brought to a close with the annual Section dinner and a short entertainment feature.

NEW BOOKS

Farm Power and Machinery Management (laboratory manual and workbook, second edition) by Donnell Hunt. 143 pages, 8½ x 11 inches. Illustrated and Indexed. The Iowa State College Press, Ames. $3.50.

The manual was prepared as a workbook and laboratory manual for a collegiate course in the study of farm power and machinery and is designed for use with a lecture-recitation type of classroom study. Sections of the manual cover problem solving, machine efficiency, costs of using farm machinery, tillage, seedbed preparation, cultivation equipment, machine calibration, performance efficiency, forage machinery, farm processing machinery, economics of machinery selection, farm power, and the farm tractor.

Well-chosen illustrations and schematic drawings present the student with a good visual background for the problems under discussion. Work sheets and laboratory exercises are easy to read and handy to fill out, both in the classroom and in the field.

Methods of Teaching Farm Mechanics (third edition) by V. J. Morford. Spiral ring bound, 126 pages, 8½ x 11 inches. Illustrated. Burgess Publishing Co., 426 South 6th St., Minneapolis 15, Minn. $3.50.

The introduction of the manual explains that it was written specifically for use as a workshop guide for agricultural education students. The course content has been organized so as to provide the student with practical training and experience in preparation for the actual teaching of farm mechanics in the vocational agriculture program.

The manual is divided into the following divisions: Planning the physical plant for teaching; selecting tools and equipment for teaching; planning the teaching program; selecting supplies for teaching; selection of teaching materials; and presentation of teaching demonstrations.

Teaching demonstrations are outlined for the fields of farm power and machinery, farm buildings and conveniences, soil and water management, rural electrification, and farm shop work.

Foundation Engineering by Rolt Hammond. Cloth, 192 pages, 6 x 9 inches. Illustrated and indexed. Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. $10.00.

Soil mechanics and site exploration; foundations for buildings, bridges, maritime structures and precision machinery; and difficult problems of special interest are covered in a practical and thorough manner. Over 100 photographs and line drawings are used to illustrate and amplify the author's explanations and descriptions.

Machine Design by Joseph Edward Shigley. Cloth, xiii+523 pages, 6 x 9 inches Illustrated and indexed. McGraw-Hill Book Co., 330 West 42nd St., New York 36, N.Y. $7.75.

A method of analysis or synthesis is introduced in this book for the purpose of developing the latent creative ability of the reader. This is accomplished by emphasizing synthesis; by requiring the reader to make decisions and assumptions and to choose the method of analysis in solving the problems; and by suggesting how present methods of design and analysis can be improved.

The book is written as a text for students in engineering. Part I is devoted to a study of the design of fundamental machine members and Part II applies the principles developed in Part I.

NEWS SECTION

Overholt Elected ASAE Fellow

(Continued from page 422)

extension specialist and has been in this position since that time except for leaves of absence for professional improvement. In 1921 and 1922 he took advanced studies in drainage and hydraulics at the University of Wisconsin, and in 1939 took advanced work in the Ohio State University graduate school.

Of his many achievements in the soil and water field, several are outstanding. He has been instrumental in pioneering and developing improved farm drainage practices in Ohio over the past 40 years by effective teaching and practical demonstrations. As early as 1920, he initiated a program of erosion control at a time when there was little interest in the conservation of soil and water. He has made an outstanding contribution to the development of safe and adequate water supply and waste disposal systems on Ohio farms. Early in his extension career he instituted a program of farm pond development to augment farm water supply. His activities in the field of irrigation span his extension career beginning with vegetable crops and expanding in recent years to field crops. He has served as a consultant to various federal, state and local agencies, and trade associations.

His outside activities have aided in many extension programs. He is a member of the Governor's Committee on Water Resources, the State Farm Bureau Committee on Drainage Legislation and Water Rights and the Farm Water Task Force of the Ohio State Forestry Association, and has helped develop drainage criteria for the Ohio Turnpike Commission.

He has been chairman of the Soil and Water Division of ASAE and is at present a member of its Committee on Specifications for Design and Construction of Tile Drains, Committee on Surface Drainage, and Committee on Interrelations of Highway and Agricultural Drainage. He is the author of many papers in his field and has presented several papers at ASAE meetings.

EJC Proceedings Available

THE 1956 proceedings of the general assembly of Engineers Joint Council, with which ASAE is now affiliated as an "associate society," are now available.

The 68-page publication is a complete transcript of a two-day meeting devoted to the following four subjects: Technical Manpower and the Reserve Forces Act of 1955, Extending Engineering Manpower by Utilizing Balanced Teams of Engineers and Engineering Technicians, Growth Pattern of the Engineer, and The Hoover Commission Reports — A Review of the Engineering Aspects.

Anyone interested can obtain a copy of these proceedings at $1.00 each from Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

ACAPA Elects New Officers

J. J. SEALE, Concrete Conduit Co., Colton, Calif., was elected president of the American Concrete Agricultural Pipe Association during the Association's 6th annual convention held at the Brown Palace Hotel in Denver, April 12 to 14. Other officers included Bruce N. Spencer, Jr., Gifford-Hill-Western, Inc., and Homer Peterson, Rockite Silo, Inc., vice-presidents; Glenn Harriman, Indiana Lock Joint Concrete Pipe Co., secretary, and William B. Freeman, Lock Joint Pipe Co., treasurer. Directors are Earl H. Eby, Elk River Concrete Products Co. G. D. Williamson, Valley Concrete Pipe Products Co., and Charles E. Ward, Utah Concrete Pipe Co.

The meeting was highlighted by two papers presented by engineers from the U.S. Bureau of Reclamation; by a paper presented by Philip W. Manson, professor of agricultural engineering, University of Minnesota, and by an interesting technical discussion of a new specification for irrigation pipelines by Arthur F. Pillsbury, University of California, Tyler H. Quackenbush, irrigation engineer, Washington, D. C., and Lester F. Lawhon, engineer, Soil Conservation Service, USDA.

James E. Mandry, assistant head, canals and pipe line section, U.S. Bureau of Reclamation, spoke on full-pressure concrete pipe distribution systems. Lewis H. Tuthill, chief, laboratory, U.S. Bureau of Reclamation, spoke on some aspects on control and behavior of concrete. Philip W. Manson, recently named chairman of a committee of the American Society for Testing Materials to supervise and recommend revisions to specifications for concrete irrigation pipe and concrete draintile, discussed junction studies that have been made at the University of Minnesota. He suggested the use of a hydrostatic test to determine the quality of tile in addition to or in place of some of the present tests. He did not suggest breaking the tile by this means but rather to determine its resistance to the passage of water under head.

Mr. Quackenbush urged cooperation between the American Concrete Agricultural Pipe Association and the U.S. Soil Conservation Service engineers in the development of specifications for the installation of concrete irrigation pipe lines.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Anderson, Joseph D. — Student, University of Idaho (Mail) Genesee, Idaho

Barrett, John R., Jr. — U.S. Army (Mail) 625 Summers, Dyersburg, Tenn.

Bell, Donald H. — Bell Engineering Co., RR 2, Box 236, Lake Worth, Fla.

Benanchietti, Omero E.—Application engineer, General Electric, Fort Wayne, Ind. (Mail) 6106 Kent Road

Bobb, James E.—Farm administrator, Milton Hershey Farms, Hershey, Pa. (Mail) 278 E Chocolate Ave.

Brockett, Glenn S.—Development engineer, Massey-Harris-Ferguson Ltd. (Mail) 73 Scarboro Hts. Blvd., Toronto 13, Ontario, Canada

Brown, Ernest E.—General engineering aid, USDA, agricultural engineering dept., Michigan State University, (Mail) 902-A Birch Road, East Lansing, Michigan

Carson, William M., Jr. — John Deere Waterloo Tractor Works, Waterloo, Iowa (Mail) 687 W. Butterfield, Weiser, Idaho

Clausen, Howard F.—Product design engineer, John Deere Wagon Works, Moline, Illinois

Correll, Ronald G.—Student, University of Idaho, Moscow, Idaho (Mail) PO Box 89

Dailey, Carl W.—Student engineer, John Deere Harvester Works, East Moline, Ill. (Mail) Box 332, YMCA, Moline

Darnell, Millard K. — Training program, Caterpillar Tractor Co., Peoria, Ill. (Mail) Minier

De Klerk, Andre—Lieutenant, building design and administration, H. Q. Unit, Pretoria, South Africa (Mail) 203 Eland House

Dearborn, Richard H. — Sales manager, Storm Manufacturing Div., Western Brass Works, Torrance, Calif. (Mail) P.O. Box 292

Duffy, Irving A. — Vice-president, Ford Motor Co., General manager, Tractor & Implement Div., 2500 E. Maple Road, Birmingham, Michigan

Easley, Bob L. — Agricultural engineer, Branch of land Operations, Crownpoint, New Mexico (Mail) General Delivery

Farnan, Edward H., Jr. — Engineering trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 756 Forest Ave., Larchmont, New York

Hammond, George B. — Project engineer, Lilliston Implement Co., P.O. Drawer 871, Albany, Ga.

Hartman, Mark K.—Director of sales and public relations, Western Farmers Electric Cooperative, Box 510, Anadarko, Okla.

Haynes, Howard D.—Agricultural representative, Caterpillar Tractor Co., Sales Development Div., Peoria, Ill.

Hett, George M. — Manager and major shareholder, George Hett Ltd., 3623 W. Broadway, Vancouver 8, B.C.

Hoppert, Frederic M.—Staff assistant, Inland Steel Products Co., 4101 W. Burnham, P. O. Box 393, Milwaukee 1, Wis.

Hussey, William D. — Owner, Superior Pump and Sprinkler Service, 7153 Hussey Drive, Carmichael, Calif.

Kindle, J. J.—Design engineer International Harvester Co., East Moline Works, East Moline, Illinois

King, Verl G.—Agricultural engineer, U.S. Dept. of Agriculture, SCS, Burdette Bldg., Walnut St., Shoshone, Idaho

Kittridge, Charles W.—Extension marketing assistant, Maine Agricultural Extension Service, University of Maine (Mail) Box 752 Postoffice Bldg., Presque Isle, Maine

Leonard, Ronald K.—Product design engineer, John Deere Des Moines Works, (Mail) RR 3, c/o O. W. Reinholz, Ames, Iowa

Lindquist, John F. — Student, Kansas State College (Mail) 2630 Virginia, Topeka, Kans.

Musser, Earl C.—Designer, Allis-Chalmers Mfg. Co., Gadsden Works (Mail) 2009 Lookout St., Gadsden, Ala.

Miller, Henry A. — Agricultural engineer, Soil Conservation Service, Dadeville, Ala. (Mail) P.O. Box 526, Decatur, Ala.

Miller, Noel H. — Sales engineer, Moline Manufacturing Co., Racine, Wis.

Moseley, Yack C.—Graduate assistant, agricultural engineering dept., Oklahoma A & M College, Stillwater, Okla.

Murphy, J. A.—Instructor of farm machinery courses, agricultural engineering dept., Clemson Agricultural College, Clemson, South Carolina

Nitsch, Milton W.—Student, Texas A & M (Mail) Box 942, Fairbanks, Texas

O'Harrow, David D.—Student, University of Idaho (Mail) RR 1, Twin Falls, Idaho

(Continued on page 444)

How big should a farmer's toolbox be?

Ordinarily a look into a farmer's toolbox would find an assortment of hand tools, some nuts and bolts, even an electric drill. Close by might be other hand and power tools too big for his toolbox. But there's another set of farm "tools" that has yet to be found in any farmer's toolbox. And it belongs. *The livestock buildings.*

Compared to mechanization of field work, mechanization in and around farm buildings is in its infancy. Most farmers who have abandoned the pitchfork for modern harvesting equipment will quickly admit to the back-breaking inefficiency of storing and feeding tons of harvested materials.

The new grassland trend is to help reduce labor needs by using stock shelters as farm tools. Engineers and farmers are developing buildings for specific purposes. And they can be as flexible as an interchangeable screwdriver handle. Best of all they keep farm operations running smoothly and efficiently.

The use of machines and gravity for easy handling of grains and forages depends on building design. Self-feeding arrangements in both buildings and adjacent feedlots can be streamlined with the right tools—the correct buildings—to work with.

New Holland, in turn, continues to develop and build new and improved grassland machines that help ease the work in and around farm buildings—advanced machines like the Model 300 Spreader with the cross-conveyor attachment for automatic filling of horizontal trench or bunker silos and feed bunks.

The New Holland Machine Co., New Holland, Pa.

NEW HOLLAND

"First in Grassland Farming"

Applicants for Membership

(Continued from page 442)

Parr, George W.—Graduate training course, Allis-Chalmers, Milwaukee, Wis. (Mail) 6619 Fairfield, Houston 23, Texas

Pascal, Sitri L.—Student, Utah State Agricultural College (Mail) 846 Thorn St., Sewickley, Pa.

Petter, Johnnie A.—Production trainee, Ralston Purina Co., Ft. Worth (Mail) RR 2, West, Texas

Rice, James R.—Student, State College of Washington (Mail) Box 246, Athens, Georgia

Rodriguez, Edward C., Jr. — Safety supervisor, Cia. Shell de Venezuela, Ltd., Apartado 19, Maracaibo, Venezuela

Schapaugh, Gordon B.—Sales manager and vice-president, Frank W. Murphy Mfgr., Inc., P.O. Box 1476, Tulsa, Okla.

Sherman, George L.—State conservation engineer, U.S. Dept. of Agriculture, SCS, Raleigh, N. C. (Mail) 3428 Leonard St.

Shipley, Henry—Chief engineer, Salt River Valley Water Users Assn., Phoenix (Mail) 328 Kachina Lane, Scottsdale, Arizona

Smith, Harold I. — Assistant secretary and sales manager, John Deere Plow Co., San Francisco, Calif. (Mail) 6367 Ascot Drive, Oakland

Snyder, William L.—Student engineer, John Deere Waterloo Tractor Works (Mail) 203 N. Olive St., Lake City, Iowa

Staley, Leonard M.—Graduate student, agricultural engineering dept., University of California, Davis, Calif. (Mail) Apt. 0-10 Aggie Villa

Van Camp, James D.--Student, Agricultural Engineering Dept., West Virginia University, Morgantown, W. Va.

Van Houten, Peter F.—Graduate trainee of design engineering, Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) Campus Club, University of Idaho, Moscow, Idaho

Wilkinson, George T.—Farm representative, The Washington Water Power Co., Lewiston, Idaho (Mail) 728 Burrell

Williams, Larry G. — Student, agricultural engineering dept., University of Idaho (Mail) RR 2, Moscow, Idaho

Transfer of Membership

Barnell, L. C. — Product design engineer, Goodyear Tire & Rubber Co., Lincoln, Nebr. (Mail) 1525 S. 44th St. (Associate Member to Member)

Bhattacherjee, B. K. — Assistant agricultural engineer, Government of West Bengal, New Block, 2nd Floor, Writers' Bldgs., Calcutta 1, India (Associate Member to Member)

Parker, Blaine F. — Assistant professor, agricultural engineering dept., North Carolina State College, Raleigh, N.C. (Associate Member to Member)

Simpson, Albert N., Jr.—Agricultural engineer, Lewis and Co., 120 Wall St., New York, N. Y. (Associate Member to Member)

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency, or registration as a professional engineer.

POSITIONS OPEN 1955 — DECEMBER — O-476-786, 503-787. 1956—JANUARY—O-455-789, 534-790. FEBRUARY — O-4-601, 4-602, 6-603, 12-604, 15-605, 29-606, 22-607. MARCH —O-60-608, 60-609, 71-611, 80-612. APRIL—O-105-613, 115-614, 117-615, 117-616, 119-617, 127-618, 136-619. MAY—O-133-620, 155-621.

POSITIONS WANTED — 1955 — SEPTEMBER — W-351-41. OCTOBER—W-398-45. NOVEMBER — W-429-51, 445-52, 450-53. DECEMBER — W-458--56, 486-57, 489-58, 480-59. 1956 — JANUARY—W-457-60, 528-61, 529-62. FEBRUARY — W-8-1, W-18-5, W-30-6, W-37-7. APRIL—W-50-11, 101-12, 90-13, 96-14, 43-15, 53-16. MAY—W-125-17, 139-18, 143-19.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER for development and supervision of plans for buildings, ponds, irrigation systems, surface water control, machinery and equipment, and other engineering features on 16 outlying branch experiment stations in a southeastern state. Age 25-30. BS deg 'n agricultural engineering. Up to 3 or 4 yr of broad experience in agricultural engineering. Initiative in studying and solving engineering problems and ability to work with people. Good opportunity for advancement, and for experience with many phases of engineering while performing an important service. Salary open. O-164-622

RESEARCH ASSISTANT in agricultural engineering for cooperative project in evaluation of picking components of carding type peanut picker in a southeastern state. BS deg in agricultural engineering with "B" average or better. No experience required. Genuine interest in learning and in establishing fundamental relationships basic to the development of improved farm equipment and methods. Appointment immediate or before September 1, for 2 yr to complete MS deg requirements. One-half time on scholastic work. Salary $1800-2100 per yr. O-165-623

AGRICULTURAL ENGINEER, assistant or associate professor, for teaching and research in farm structures in a northeastern state university. Professional service, and 2-yr courses. Proportion of teaching and research somewhat adaptable to individual's desires and abilities. Major research areas could be in potato storages, poultry housing, or dairy housing. Age under 35. MS deg in agricultural engineering or equivalent, or BS deg and interest in obtaining advanced degree. Teaching and research experience in farm structures. Must be able to meet and work well with others, and aggressive in developing structures research program. Excellent opportunity in expanding department. Social Security, hospitalization, life insurance, and exceptional retirement program. Salary open. O-166-624

(Continued on page 446)

Who Should Join ASAE

If any one of the following descriptions covers your present work:

- Development, design, and application of farm tractors and implements and their components
- Design and improvement of farm buildings
- Engineered improvements for soil and water conservation and use
- Creating applications for electricity in farm practice and living—

then you can derive much benefit from membership in ASAE, and the Society cordially invites you to make application. For further information write

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
St. Joseph, Michigan

Personnel Service Bulletin

(Continued from page 444)

AGRICULTURAL ENGINEER, assistant professor, for research on crop harvesting and handling equipment and methods, with initial work on potatoes, in a northeastern state experiment station. Age under 35. MS deg in agricultural engineering or equivalent, or BS deg and interest in obtaining advanced degree. Interest in materials handling and machinery development. Experience in crop harvesting and handling desirable. Must be able to meet and work well with others. Excellent opportunity in expanding research program. Social Security, hospitalization, life insurance, and exceptional retirement program. Salary open. O-166-625

AGRICULTURAL ENGINEER, instructor, to teach physics and rural electrification to agricultural students, with opportunity for graduate study toward MS or PhD, in a north central state university. Age under 40. BS deg in agricultural engineering or equivalent, from accredited curriculum. Good academic aptitude. No work experience required. Appointment for full time or part time, depending on desired rate of graduate study program. Salary $448 per month for full time. O-167-626

AGRICULTURAL ENGINEER, assistant professor, to teach farm power on farm structures, in a southern state polytechnic institute. Age under 30. MS deg in agricultural engineering, or equivalent, and preferably a year or two of experience. Usual personal qualifications for college teaching. Yearly automatic raises and merit raises. Third man in rapidly growing agricultural engineering department. Salary open. O-159-627

AGRICULTURAL ENGINEER for teaching, extension and research as rural electrification project director in a northwestern state. Age 25-45. BS deg in agricultural engineering, preferably from an accredited curriculum. Teaching or research experience or work with a power supplier. Ability to work and cooperate with others. Interest in writing. Registered professional engineer or interest in qualifying for registration. Better than average opportunity for advancement. Salary open. O-142-628

AGRICULTURAL ENGINEER, associate or assistant professor, to teach irrigation, soil and water conservation, farm surveying, serve on irrigation research advisory committee for the Agricultural School; and plan and initiate irrigation research in the agriculturing engineering department, at a southwestern state college. MS or higher degree in agricultural engineering, or equivalent, with advanced study in irrigation planning and research, and in experimental or statistical analysis. Usual high personal qualifications for college teaching. Excellent opportunity for aggressive man in area with 40,000 deep wells and 4 million acres under irrigation. Permanent position with nine-month contract renewed annually. Salary $5400 maximum to start, with 10 percent raise at beginning of second year, and additional pay for summer work. O-173-629

AGRICULTURAL or MECHANICAL ENGINEER for design and development of crop drying equipment, and application research in this field, with established organization in Midwest. Age 25-30. BS deg in agricultural engineering. At least 2 yr experience in equipment manufacture or sales. Should be able to take full responsibility for development projects and technical work on sales promotion. Excellent opportunity in expanding organization. Salary $5000 minimum starting. O-175-630

AGRICULTURAL or MECHANICAL ENGINEER for chief product design and development engineering position with long-established and expanding eastern manufacturer of agricultural steel products. Responsible for new product design and development from concept to final finished items. Age 30-40. BS deg in mechanical engineering, or equivalent. Approximately 10 years experience in metal product design and development. Some knowledge of farm machinery desirable. Capacity for sound accurate judgment and follow-through in all stages of product development. Good opportunity for advancement. Participation in profit sharing plan. Salary $12,000-15,000. Include present position and salary in resume of personal data. O-179-631.

AGRICULTURAL ENGINEER, Associate professor, for research in field machinery, in agricultural engineering department of a land grant University in the East. PhD with major training or experience in mechanics and machine design, and technical competence in modern instrumentation for stress analysis. Experience in farm equipment industry desirable. Must be able to cooperate effectively with other agricultural engineers, other subject matter specialists and farmers; and to organize and direct research. New building with modern facilities and equipment provides opportunity for competent research man to make an outstanding contribution to agricultural engineering. Send complete personal data, including transcript of college records and 3 references who can evaluate technical qualifications. Salary $6948. O-181-632

AGRICULTURAL ENGINEER, assistant professor, for extension program in crop processing and materials handling equipment, in an eastern state with an agricultural engineering extension staff of 10 specialists directed by a project leader. MS deg in agricultural engineering with major interest in machinery and farmstead equipment. Farm background. Preferably some extension experience. Keen interest in working with farmers and genuine ability to cooperate with other workers. Opportunity to develop intensive educational and demonstration program in specialized field. Send complete personal data including transcript of college records and published writings. Salary $6210. O-181-633

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for extension, teaching, research, sales, or service in power and machinery, farm structures, or rural electric fields, with public service or industry, anywhere in USA or elsewhere. Married. Age 38. No disability. BS deg in agriculture, 1941; MS deg in agricultural enigneering, 1946, both at Michigan State University. Farm background, taught vocational agriculture and farm shop 13 yr. Farm machinery advisor, ICA, Pakistan, 2 yr. Available Jan. 1, 1957. Salary open. W-161-20

AGRICULTURAL ENGINEER for sales or research in power and machinery or rural electric field with industry or public service in southeastern Wisconsin. Age 29. No disability. BS deg in agricultural engineering, 1951, University of Arkansas. MS deg in agricultural engineering, 1955, Pennsylvania State University. Farm background. Tractor engineering 2 yr, including proving ground, laboratory, and design. War and postwar enlisted and commissioned service, 4 yr in Army Engineers and Signal Corps. Available July 1. Salary open. W-149-21

AGRICULTURAL ENGINEER for extension, teaching, or research in soil and water field with public service or manufacturer anywhere in USA. Married. Age 26. No disability. BS deg in agricultural engineering, 1951, MS deg in agricultural engineering expected, August 1956, both at University of Missouri. Farm background. Graduate research. USAF 4 yr, including 3 yr as weather forecaster. Available Sept. 1. Salary open. W-122-22

Index to Advertisers

Professional Directory

RATES: 80 cents per line per issue; 40 cents per line to ASAE members. Minimum charge, five-line basis. Uniform style setup. Copy must be received by first of month of publication.

FACTS

about

NEW DEPARTURE
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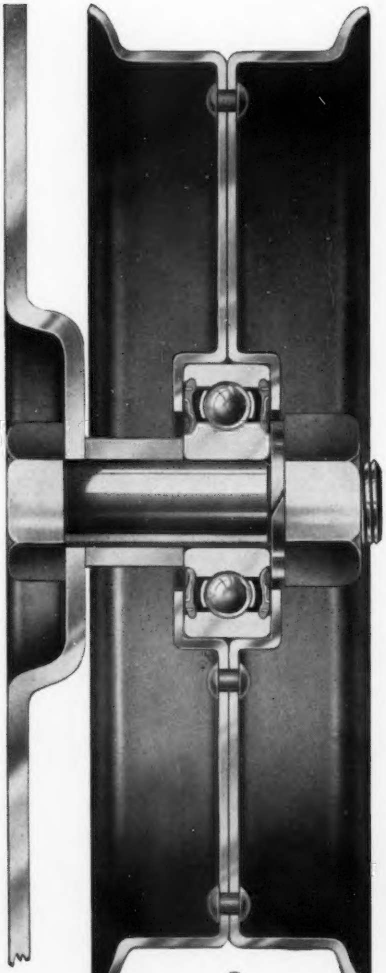
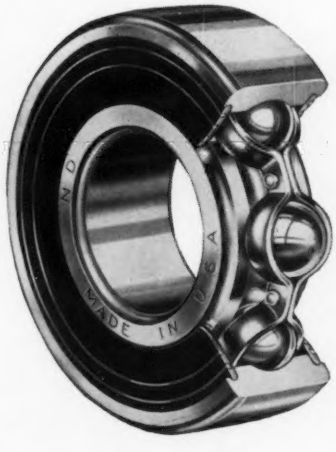


IDLER PULLEY UNITS FOR FAST, LOW-COST MOUNTINGS

These NEW Departures in farm implement components are built around New Departure ball bearings equipped with Sentri-Seals—"always on guard against dirt."

Permanently lubricated with special, high-quality ball bearing grease, and Sealed-for-Life, these units require no relubrication . . . no maintenance of any kind. They literally are "built-to-be-forgotten" for service . . . for greatest economy and customer satisfaction.

Bearing bores are sized to mount on standard bolts for fast, low-cost mounting. Pulleys are of strong, riveted construction with edges rolled to prevent belt damage and give additional strength.



These NEW Departures are available for both flat and V-belts . . . for harvesters, balers, spreaders, combines and many other farm implement applications. Write for details.

SENTRI-SEAL
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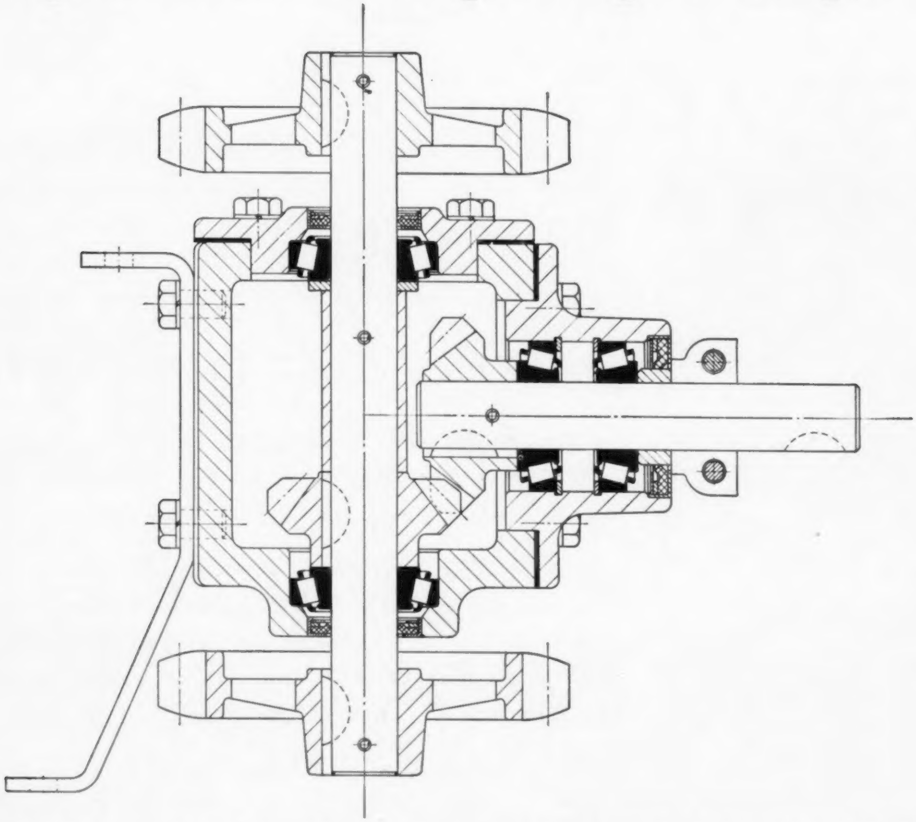
BALL BEARINGS MAKE GOOD MACHINES BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

EVERY MAKE OF FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

How Minneapolis-Moline keeps shafts aligned, lengthens life of corn picker gear box parts



ONE big reason for the longer life of moving parts in the Minneapolis-Moline Mounted Corn Picker is that the gear box is equipped with Timken® bearings.

Timken tapered roller bearings in the small gathering chain gear box hold shafts in rigid alignment because they take both radial and thrust loads in any combination. Gears mesh smoothly and accurately, wear less. It's the tapered construction that does it. And full line contact between rollers and races gives Timken bearings extra load-carrying capacity.

Because Timken bearings keep housings and shafts concentric, closures are more effective. Dirt and moisture can't get in. Lubricant can't get out. Maintenance is further reduced—one lubrication a season is usually plenty.

Timken bearings save power, too. That's because they practically eliminate friction. They're designed by geometrical law to have true rolling motion and are manufactured with microscopic accuracy to live up to their design.

With Timken bearings, agricultural engineers find ready answers to three of their biggest design problems: 1) combination loads, 2) dirt, 3) ease of operation. Engineers can depend upon Timken bearings to help equipment operate more easily and economically, last longer. We even make our own bearing steel, to be sure it's the finest available. We're America's only bearing manufacturer that does.

For helpful design ideas on applications for Timken bearings, write for your free copy of "Tapered Roller Bearing Practice In Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

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NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION